HE ENGINEERING CONSTRUCTION WEEKLY

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June 23, 1938

Mixing soil and cement in road base stabilization

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. ENGINEERING NEWS-RECORD .

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Vol. 120 *JUNE 23, 1938* No. 25

THIS WEEK

A LOW-COST all-season type of highway surfacing is the objective of Portland Cement Association engineers who have been making extensive studies of the physical properties of different soil-cement mixtures. The laboratory phase of these investigations is covered in this issue, and will be followed by a field story in the issue of July 7.

Four months after a steel arch span at Rumford, Me., was built with a waterway opening sufficient to pass a 60,000-sec.-ft. flood, a 74,000-sec.-ft. discharge came along. Repairs and provision for greater flow are described on page 876.

Garbage disposal in conjunction with sludge digestion is a feature of the new sewage disposal plant at Lansing, Mich.

Following an article last week on laboratory tests made on structural plywood at Stanford University, three Pennsylvania State College men tell of tests made there using this plywood for gusset plates.

Orange County, Calif., has been trying since 1929 to finance storage dams and other means of flood control. Now, with the help of federal aid, it is ready to go ahead with its program.

In 1936 carbon dioxide in Los Angeles Aqueduct water was producing an acid condition of sufficient intensity to stimulate corrosion in steel pipes. A report of the successful cure of this condition is published on page 885.

NEXT WEEK

CONSTRUCTION COST GUIDE

Statistical facts necessary for successful project planning and bidding, formerly published and sold as a separate book, "Construction Costs", *will be presented in a regular number of* News-Record. *A 75-page issue within an issue.*

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The cover picture shows a spring-tooth harrow mixing cement and soil in highway stabilization work. The first of two articles on this important subject is on page 869.

Number of copies of this issue printed: 33,230

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—all three with one cast!

MONTGOMERY WARD & CO. RETAIL DEPARTMENT STORE

Architectural concrete made with Universal Atlas Cement was used in the Montgomery Ward & Co. building, Menands, N. Y. Original unit designed by the Construction and Equipment Dept. of Montgomery Ward & Co., and constructed by Wells Brothers, Chicago. The addition was both designed and constructed by the Construction and Equipment Dept.

With architectural concrete made with Universal Atlas Cement, concrete structural parts and ornamentation are cast as a unit

INDUSTRIAL construction dresses up! Drabness gives way to striking new beauty—usually at a saving in cost. Architectural concrete makes this possible. With architectural concrete the concrete structural parts and ornamentations are cast as a unit. Thus to the strength, durability and fire safety of concrete is added a new element of beauty which opens interesting new possibilities in the field of construction.

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· ENGINEERING NEWS-RECORD ·
JUNE 23, 1938

THE WEEK'S EVENTS

TVA Dam Cost Is Allocated

Power, flood control, and navigation are assigned 52, 20, and 28 per cent of cost of three dams

Fifty-two per cent of the cost of the three completed TVA dams, Wilson, Norris and Wheeler, is charged to power in an allocation submitted to the President by TVA on June 16. The President immediately approved the recommendation. The allocation was made nearly a year and a half after the time limit set by Congress under the TVA act as amended.

Flood control is charged with 20 per cent of the $94,126,000 cost of the three dams, and 28 per cent is charged to navigation. No part of the capital cost is assigned to national defense or fertilizer.

Three cost divisions

The TVA act called for the allocation of cost between flood control, navigation, fertilizer production, national defense, and power development. In its findings, the TVA committee on financial policy made no allocation to either fertilizer or national defense on the assumption that national defense is not a continuing function and that power used in fertilizer production would be paid for as required and, hence, has no capital cost.

The TVA investment in the three completed projects is as follows:

Wilson Dam	$30,120,009
Norris Dam	31,532,120
Wheeler Dam	32,473,542
TOTAL	$94,125,672

These figures represent the cost of construction of Wheeler and Norris Dams and a "present value" of $30,120,000 for the dam and power plant at Muscle Shoals, as against the total original cost of about $48,000,000. Interest during construction is not included because this cost is not actually incurred by the TVA. Likewise, certain charges for workmen's compensation which are borne by the U. S. Employees Compensation Commission are not included.

In arriving at project costs, nonproject costs were excluded. Thus at Norris Dam, the depreciated cost of Norris Village, amounting to $3,722,135 and the cost of two parks were excluded.

In making the allocation, the cost of facilities used for only one purpose was charged entirely to that purpose and jointly used facilities were distributed 25 per cent to flood control, 35 per cent to navigation, and 40 per cent to power, as shown in the accompanying table.

Valuation theories

The 25-35-40 ratio used in assigning costs of jointly used facilities is admittedly an assumption based largely on judgment and opinion. The finance policy committee of TVA, however, was guided by a number of cost theories, among which the greatest weight was given to the "alternative justifiable expenditure" theory. According to this theory, cost is allocated to different purposes in proportion to the estimated cost of obtaining similar results by single purpose structures.

Power rate structure

While no discussion of power revenues was made in the report itself, the letter of transmittal, signed by Chairman H. A. Morgan, and Director D. E. Lilienthal, states that, according to TVA estimates, power revenues derived from the three completed projects and sold at existing wholesale rate schedules will cover all of the cost of operation, including depreciation and 3 per cent interest on the power investment, and in addition will return the entire

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Rail Bridge Washout Kills Forty Seven

Flash flood washes out Montana railway bridge, wrecking passenger train

About 47 people were killed June 19 when a passenger train of the Chicago, Milwaukee, St. Paul & Pacific R.R. plunged into Custer Creek about 25 miles east of Miles City. A cloudburst a few miles upstream had undermined the piers of a deck bridge. Six cars, including two coaches, two tourist sleepers, a baggage car and a mail car followed the engine to the far bank of the stream. Two pullmans and an observation car remained upright on the east embankment.

The bridge, which was 25 years old, consisted of three 50-ft. plate girder through spans 5 ft. deep resting on concrete piers with a normal clearance of 16 ft., and five 16-ft. concrete trestle spans at the west end consisting of concrete piers supporting concrete slabs and ballasted decks. The pier foundations were on gravel 10 ft. below stream bed.

The locomotive was a heavy 4-8-4 steam engine with a scheduled speed of 50 m.p.h. The bridge supported the engine until it reached the far bank and fell upstream on its side, the cars piling up behind it in zigzag fashion. The first pier has been swung around; the second pier is in position but the top has been knocked out. The trestle is under the cars and engine.

The bridge had given no previous trouble during its lifetime. No floods had occurred in recent months to weaken the structure or undermine the piers. The creek is dry nine months of the year. A track walker is said to have noticed no water under the bridge shortly before the train passed at 1:10 A.M. There were no rainstorms at the site of the disaster or along the railroad.

Routine inspections of all Milwaukee bridges take place four times a year, and bridges are inspected once a year by the division engineer and chief carpenter. No repair work was found necessary at the last inspection of the Custer Creek bridge April 14.

(Continued on page 862)

Relief Works Bill Is Approved

Congress passes measure providing $3,000,000,000 for public works and relief projects

Expenditures of well over $3,000,000,000 are authorized by the relief and recovery bill as finally agreed upon by Congress just before adjournment, the exact total being indefinite because the bill is a mixture of direct appropriations, authorizations, loan provisions, recoverable and otherwise, and other forms of governmental spending. Highlights of the measure in its final form are:

Relief and work relief—The Senate appropriation of $1,425,000,000 to carry WPA for eight months (until Feb. 28, 1939) prevailed over the House's $1,250,000,000 for seven months. The Woodrum amendment, designed to enforce the spreading of the appropriation over the full period, was modified to give the President authority, as an emergency measure, to spend the full amount in seven months if necessary. Of this amount not more than $25,000,000 may be used for direct relief, as contrasted with work relief.

In addition, appropriations are made for other relief activities as follows: National Youth Administration, $75,000,000; Farm Security Administration, $175,000,000; Puerto Rico Reconstruction Administration, $6,000,000; National Resources Committee, $750,000. Miscellaneous grants to various departments and agencies for administrative expenses bring the total under Title I to $1,712,905,000 plus unexpended balances from the current fiscal year.

Public works—The Public Works Administration has its life extended to June 30, 1941, and is given an appropriation of $965,000,000, of which not more than $750,000,000 can be used for grants or other non-recoverable expenses. It can also use not more than $400,000,000 of receipts from bond sales as a revolving fund. This money can be used for federal or non-federal projects, (the former being limited to $200,000,000) which can be started by Jan. 1, 1939, and completed by June 30, 1940.

Project applications must be made to PWA by September 30, 1938. Projects under injunction are exempted from the completion time limit. Grants are limited, as before, to a 45 per cent basis. There is no restriction on power loans, but the President has agreed not to approve loans for competing power facilities until a *bona-fide* offer has been made to purchase such facilities at a fair price.

Federal building program—The present three-year program for the construction of public buildings outside of the District of Columbia is increased from the previously authorized $70,000,000 to $130,000,000, of which $25,000,000 is immediately available.

Rural electrification—In addition to the regular appropriation of $40,000,000 for loans to rural electrification enterprises by REA, that agency is given authority to borrow an additional $100,000,000 from RFC for the same purpose. This authority expires June 30, 1939.

Parity payments—The sum of $212,000,000 is appropriated to provide for price-adjustment payments to farmers in the event that prices of wheat, cotton, corn, tobacco or rice fall below certain prescribed levels.

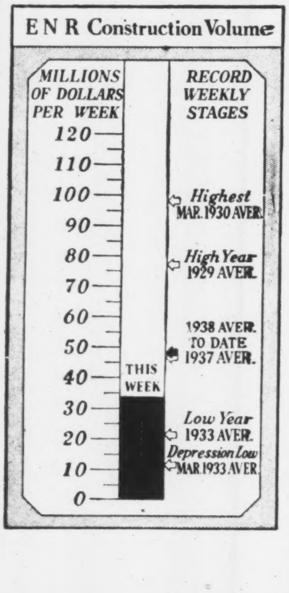
Low-rent housing—The U. S. Housing Authority is given authority to issue bonds to the extent of $800,000,000, an increase of $300,000,000 over the present limitation, to finance the construction of slum-clearance housing projects. It may also enter into contracts to a maximum amount of $28,000,000 annually as contributions to the carrying costs of such developments in order to bring rentals down to a level within the reach of the lowest income group. A Senate proposal to permit U.S.H.A. to carry 100 per cent of the cost of such projects during the construction period was deleted from the bill in conference, leaving it still necessary for local authorities to raise 10 per cent of the cost before a loan contract can be signed.

CONTRACTS AND CAPITAL

Heavy construction awards for this week total $33,572,000, a 15 per cent gain over the preceding week, but 71 per cent below the corresponding week last year when 1937's highest weekly award volume was reported.

The current week's total brings the construction volume for 25 weeks of 1938 to $1,187,311,000, 5 per cent below the 25-week total for 1937. This is the first time in 1938 that cumulative construction awards dropped below a year ago.

Private construction for the week is 55 per cent above last week, but 84 per cent below the 1937 week. Public awards are 1.5 per cent above the preceding week, but 52 per cent under a year ago.



New construction capital for the week, $26,355,000, is 186 per cent above the 1937 week. Of the total, $22,924,000 is state and municipal, $1,960,000 corporate security issues, and $1,471,000 is RFC loans to municipalities. New capital for the year to date, $787,999,000, is 32 per cent above the 25-week period in 1937.

CONTRACTS

(Thousands of dollars)

	Week Ending June 24 1937	June 16 1938	June 23 1938
Federal	$4,761	$338	$3,672
State & Municipal	40,854	21,434	18,426
Total public...	$45,615	$21,772	$22,098
Total private...	69,915	7,415	11,474
TOTALS	$115,530	$29,187	$33,572

Cumulative
1938 (25 weeks).......$1,187,311
1937 (25 weeks).......$1,245,428

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

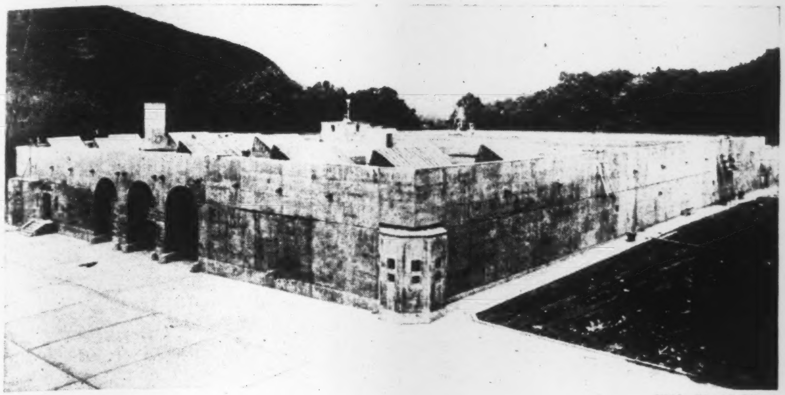
	Cumulative 1937 25 Wk.	1938 25 Wk.
NON-FEDERAL	$598,073	$701,467
State & Mun. bonds...	256,827	341,382
Corporate securities...	268,992	181,688
PWA loans, grants....	42,315	2,036
RFC loans............	29,939	65,291
U.S.H.A. loans.........	......	111,070
FEDERAL	......	$86,532
TOTAL CAPITAL.....	$598,073	$787,999

FHA MORTGAGES

	Cumulative 1937 24 Wk.	1938 24 Wk.
Mortg. selected for appraisal	$312,104	$419,489

ENR INDEX NUMBERS

Index Base	1913	1926
Construction Cost (June)...	236.86	113.86
Building Cost (June)......	198.22	107.15
Construction Volume (May)	167.00	73.00



Wide World Photo

ANOTHER PENNY BANK FOR THE TREASURY

A BILLION DOLLARS worth of silver will be moved to this concrete warehouse at the West Point Military Academy reservation shortly after its completion, about July 1. The $528,000 concrete structure contains 23 vaults, each capable of holding 100,000 70-lb. bars.

Chicago A.G.C. President Defends WPA Program

Speaking at a meeting of the Memphis chapter of the Associated General Contractors, June 9, Oscar W. Rosenthal, president of the Chicago chapter, attacked contractors who "wisecrack at WPA because it doesn't fit in with their own selfish interests," and said that the construction industry must reform itself before it would be in a position to criticise the federal relief program.

"If we can't offer something better than what WPA has done in the emergency," he said, "we have certainly no right to knock their efforts. . .

"When the construction industry is honest with itself, then it will receive a square play from the public. . .

"The industry must be big enough, in a time of great distress, to disregard the question of whether its rights have been invaded."

• • •

PWA Has Fifth Birthday

As legislation providing for a new $965,000,000 PWA program went through the final stages of presidential approval, the Public Works Administration on June 16 passed its fifth birthday.

During the past five years, PWA has allotted funds for 26,445 projects costing $4,338,368,000. All but 1,406 of these projects have been completed and of the uncompleted projects 90 per cent are under construction.

A total of 5,447,487,000 man-hours of work have been provided by the PWA program, according to PWA estimates. Of this, 1,556,425,000 man-hours was at construction sites and 3,891,062,000 was used in the production of raw material, fabrication, and transportation.

• • •

Second Deficiency Bill Passes Congress

Outstanding items in the second deficiency bill of 1938, approved by both Houses in the final hours of Congress, include an appropriation of $5,000,000 to be allotted by the President for water conservation projects in arid regions, which are not to cost more than $50,000 per project.

The Navy receives an appropriation of $12,752,000 for improvements at the Navy Yard, the Treasury Department $6,000,000 for War Department and Social Security Board buildings in Washington, and the Corps of Engineers is permitted to use $6,000,000 of relief funds, earmarked for flood control in the War Department's civil appropriation bill, in the lower Mississippi Valley. The U. S. Housing Authority receives $3,500,000 for administrative expenses.

The Bureau of Reclamation receives $975,000 from the Reclamation Fund to carry on work on the Salt River, Yuma, Klamath, and Riverton projects and to start the Tucumcari project. Unexpended balances from the current year were made available to the repayment Commission of the bureau and for engineering and economic investigation of proposed new projects.

The National Park Service receives $5,743,000 for the Blue Ridge and Natchez Trace parkways, roads and trails in national parks, and land acquisitions in the Great Smoky Park.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

THE TVA investigating committee was voted an additional $100,000 just before Congress adjourned. This brings to $130,000 the funds provided for the inquiry, relieving the shortage of funds which it had been thought might curtail its scope. Committee headquarters will be set up shortly at Knoxville, and hearings will begin there about July 20.

TOM PANTER, engineer of the Los Angeles Power and Light Board, has been appointed engineer for the committee. Panter, a graduate of Ohio State University, was for many years an engineer for the Niagara Power & Light Co., going to Los Angeles about 20 years ago.

HOUSING FUNDS will continue to be earmarked for Georgia cities, and loan contracts will be approved, even though a test suit challenging the constitutionality of the Housing Authority law of the state is now pending in the state courts, Nathan Straus, U.S.H.A. Administrator, has announced. A $1,369,000 contract with Augusta was approved early this month by the President.

THE RENTALS charged at University Homes, low cost housing project in Atlanta, were ordered reduced on June 14 by Nathan Straus, Administrator of the U. S. Housing Authority. University Homes, a $2,592,000 PWA-built project, is now being administered by the U.S.H.A. The present reductions will bring the average shelter rental on the 675 dwellings from $5.87 per room per month to an average of $4.30. Gross rents, including heat, hot water and electricity, are reduced from an average of $7.14 per room per month to an average of $5.86.

FOREST RESOURCES of the United States will be investigated by a joint committee of Congress during the Congressional recess, according to the terms of a joint resolution passed by both houses. The committee, which is directed to report not later than April 1, 1939, is directed to study "the present and prospective situation with respect to the forest land of the United States, its condition, ownership, and management, as it affects a balanced timber budget, watershed protection, and flood control" and to recommend needed legislation.

U. S. Will Carry All Flood Costs

All major flood control structures federally financed in new flood control bill

Full assumption by the federal government of all costs in connection with dams, reservoirs and channel improvements for flood control becomes an accepted governmental policy with the passage of the 1938 flood-control authorization bill, approved during the closing hours of Congress. After much jockeying between the two houses of Congress, the bill, as finally enacted, contains a broad provision that not only makes mandatory the federal ownership of title to lands, flowage rights, and rights-of-way needed for such projects, but also includes in this classification the costs of relocating or reconstructing roads, railways and other utilities.

This policy is made retroactive, applying both to the new projects authorized in the current bill, and also to those approved as far back as 1928. Expenses already incurred by local authorities will be reimbursed. New land acquisitions for flood-control dams, reservoirs, and channel improvements may be made through the local authorities, with full reimbursement or, if preferred, by direct purchase or condemnation by the federal government.

It should be noted that local authorities are still required to provide lands, flowage rights and rights-of-way for local protective works, including flood walls and levees.

Reimbursement of local authorities for contributions already made by the Muskingum Conservancy District, Ohio, to the extent of $1,500,000, and by the state of South Carolina for the Clarks Hill project on the Savannah River ($1,700,000) was specifically directed.

The Senate also threw out of the bill a revised declaration of policy that could have been interpreted as giving complete control over waterways to the army and added amendments giving the Federal Power Commission a considerable measure of authority over projects on which incidental power might be developed.

The new authority of the Federal Power Commission comes from a revision of the provision directing the installation of penstocks in any flood control dam by which surplus power might become available. The flood control act of 1936 made such installations optional at the discretion of the Chief of Engineers. The revised policy makes such a facility mandatory "when approved by the Secretary of War upon the recommendation of the Chief of Engineers and of the Federal Power Commission."

The bill also carries an authorization of $1,500,000 for the expenses of the FPC in making necessary surveys and investigations during the next five years, in addition to $5,000,000 each to the Corps of Engineers and the Department of Agriculture for similar purposes in their respective fields of direct flood control and indirect watershed improvements. These amounts are over and above the authorization of $375,000,000 for carrying out the projects approved in the bill, bringing the total authorization to $386,500,000.

No change in the amount of authorizations was made to compensate for the additional projects added by the Senate, nor for the increased cost to the federal government involved in the assumption of complete financial responsibility for certain classes of projects.

• • •

Texas Bridge Washout Wrecks Train

A Fort Worth & Denver R.R. train plunged through a washed out bridge over the South Fork of the Red River near Wellington, Texas, on June 16. Two trainmen are missing.

• • •

Wooden Bridge in Florida Partially Burned

Fire destroyed about 950 ft. of a 3,000 ft. timber bridge across North River near St. Augustine, Fla. on June 13. Damage to the bridge was estimated by the state highway department at about $80,000, and power and telephone lines were temporarily put out of service.

The highway department advertised for bids the next day for a steel bridge with concrete deck to replace the burned portion. Although connecting with the 2,000 remaining feet of the bridge, the new portion will be wider than the original.

• • •

Railway Bridge Washout Kills Forty-Seven

(*Continued from page 859*)

The present disaster is the second bridge washout on the Milwaukee line in a little more than a month. On May 18 a Milwaukee freight train broke through a wooden bridge near Rapid City, S. D. The bridge, which had been weakened by flood waters, gave way at the center.

No one was injured in this accident, but the train was wrecked and traffic was held up for some time.

Small Lots of Cement Bought From Dealers

Central cement purchasing plan modified for small quantity purchases

Exceptions are being made to the new federal policy by which all federal agencies are required to fill their cement requirements through the Procurement Division. When small quantities are needed for a particular job, purchases are being made locally through established dealers after permission to do so has been obtained from Washington. Such permission is not necessary, however for quantities of less than a single carload.

The dividing line between amounts which will be purchased from dealers and those that are to be purchased centrally is not definite. In general, the centralized purchasing plan will be utilized for quantities considered by the Procurement Division to be beyond the normal stock of established dealers.

Washington purchases

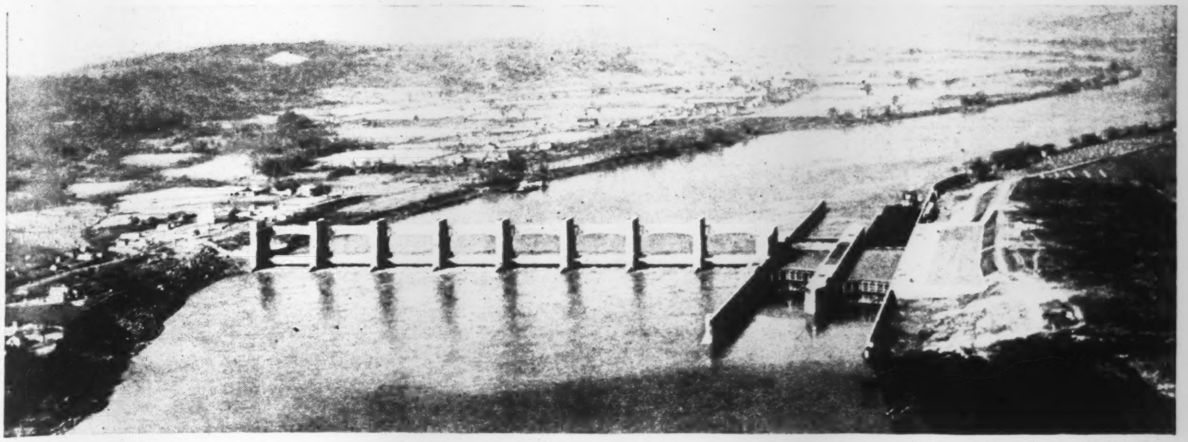
Eight bids were received on June 13 in answer to the Treasury's request for cement to be used in the state of Washington, presumably at Grand Coulee Dam. Bids were asked on two alternative schedules, one for 2,000,000 barrels of low heat portland cement to be delivered between August, 1938 and June, 1939. The other alternatate was for 5,800,000 barrels of low heat cement for delivery between August, 1938 and October, 1941.

On the first schedule the division received bids totaling 3,085,000 barrels and on the second bids totaling 7,005,000 barrels. None of the bids made any distinction in price between the two alternatives. The bids ranged from a low of $1.20 per barrel offered by Oregon Portland Cement Co. to a high of $1.70 by Spokane Portland Cement Co. This last bid was somewhat out of line, the next lowest bid being $1.50.

Utah and Colorado

Bids were received June 16 and 17 for 20,000 barrels each of finely ground and modified portland cement for use in Utah and 10,000 barrels of each type for use in Colorado. In all four cases, the Monolith Portland Midwest Co. was low with its bid of $2.16 for finely ground and $2.20 for modified.

Bids for additional amounts of cement to be used in California and Nevada have been asked by the Procurement Division, to be opened June 30. The Division wants 75,000 barrels of finely ground standard, most of which will be used in California. Deliveries will be spread over a period of about a year.



Dravo Photo

GALLIPOLIS DAM IS DEDICATED

First roller gate dam on the Ohio River, Gallipolis Dam at Gallipolis, Ohio, was formally dedicated June 12. The eight roller gates in the dam, each 125 ft. long and 29.5 ft. high, are the largest in the world. The dam structure itself is 1,149 ft. long, containing nine piers and eight roller gates. Two navigation locks are also included.

The project was constructed for the U. S. Engineers by Dravo Corp.

City Held Not Liable For Sidewalk Break

Elevation of a concrete sidewalk slab 5½ in. above the next slab is not a condition for which the city of New Orleans is necessarily liable, the Louisiana Court of Appeals held, reversing a district court's decision awarding damages to John D. Carsey against the city.

Carsey was injured when he tripped on the projecting sidewalk slab and fell.

The appeals court held that the plaintiff had not given notice to the city of the defective condition of the sidewalk and that no evidence had been introduced to show that the defect had existed for a sufficient period of time to allow the city to be charged with constructive knowledge.

• • •

State May Not Regulate Phoenix Water System

Operations of the municipal water system of the city of Phoenix, Ariz., both inside and outside of the city, are exempt from regulation by the State Corporation Commission, the Arizona Supreme Court ruled June 9.

The court ruled that the city's water service falls within the meaning of the state law forbidding the corporation commission to regulate municipal corporations. This applies also, the court held, to operations outside the city limits. "The limitation placed by the constitution on the power of the corporation commission over municipal corporations is not predicated upon the place where they do business, but upon the fact that they are municipal corporations."

A suit had been brought by customers of the municipal water supply outside the city to prevent the city from raising its water rate.

The court pointed out that the dissatisfied customers had the option of organizing a new water supply, seeking aid from the state legislature, or seeking to amend the constitution.

• • •

Thirty Thousand Fish Pass Bonneville

The $6,750,000 fishways at Bonneville dam passed 30,105 salmon and steelhead trout during the period from May 7 to May 28, according to official figures released by the Bureau of Fisheries. The spring run of Chinook salmon accounted for the major part of the count, totaling 22.539 fish. The maximum number of Chinook passed the fishways May 10 with a count of 2,978 fish.

Fish are counted as they pass through gates built in the fish ladders. Counters are at their stations from 4 a.m. to 8 p.m. every day, and the gates are closed during the night. On several nights when counting was continued as a check on the activity of fish during the hours of darkness, the night count amounted to only about 4 per cent of the day count.

The low counts at Bonneville are attributed by the bureau to the late arrival of the salmon runs this year and the exceptionally high stage of the river. A scarcity of fish is also being observed in the 40-mile stretch of the river immediately below the dam.

Eight Ohio River States Sign Pollution Pact

Representatives from eight states on June 13 signed the Ohio River stream pollution compact, designed to clean up the Ohio River. The compact must now be ratified by the legislatures of each of the states and approved by Congress.

The compact contains a guarantee by each state that it will keep sewage and industrial pollution at a level where "it shall not injuriously affect . . . interstate waters." Under the compact, elimination of 55 per cent of total suspended solids discharged into interstate waters would be required of each signatory state.

A commission, consisting of three commissioners from each member state and three federal commissioners, would have power to order additional treatment in certain cases; orders of the commission would be enforcible in the courts.

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Cheap Loans Authorized To Canadian Cities

The loan of $30,000,000 to Canadian municipalities, at 2 per cent interest, for construction or improvement of self-liquidating utility projects is provided for in the Municipal Loan Bill, passed recently by the Dominion government.

To be eligible for a loan, the project must be such as to increase the revenue of the municipality and provide employment which is needed in the community.

Floods Recede On Yellow River

Decline in levels of early flood reported as water spreads over wide area on river delta

Latest reports from China state that the flood crest in the Yellow River has fallen somewhat but that waters released through breaks in the dikes near Kaifeng are spreading over a wide area to the east.

Informed persons generally discount the reports of large loss of life and abnormal damage coming from Japanese sources as being exaggerated statements put out for strategic reasons. Because of impossibility of obtaining accurate information on the ground, due to the disintegration of the engineering forces in charge of Yellow River flood control, the editors of *Engineering News-Record* asked Oliver J. Todd, former consulting engineer to the Yellow River Commission, to summarize the situation as he sees it. Mr. Todd recently returned from China. His statement follows.

The Yellow River Flood

By O. J. Todd

The Yellow River flood season starts in mid-June or a little later and runs pretty well through September. It is usually at its maximum height in late July or August. These latter floods are caused chiefly by summer rains. The spring flood or "peach-blossom flood" is of much less consequence and is the result of ice being melted in the upper reaches of the river. This flood usually reaches the Great Plain of China near Kaifeng the last week of March or the first ten days of April.

The usual flood volume in summer at the head of the Great Plain varies from 200,000 to 400,000 sec.-ft. The greatest flood recorded in modern history for this river occurred in August, 1933, and was approximately 800,000 sec.-ft. when it reached the plain. An extreme maximum anticipated by river engineers conversant with the river is 1,000,000 sec.-ft. at that point. That is close to where recent breaks have occurred north of Chengchow, Honan.

The present flood may even exceed the flood of 1935 in damage done, assuming that the coming summer flow is 500,000 sec.-ft. or more at its height. It seems very probable that major disasters will accompany this flood when account is taken of crops drowned and lands put under water for many months thus restricting new planting. The flood waters follow rather level terrain that is considered good agricultural land for the most part.

The statement that thus far an area aggregating 500 sq. mi. is under water may be accepted as true. But by midsummer this area may be increased to 6,000 sq. mi. as was the case in September, 1935. That would seriously affect a farming population of nearly 5,000,000. While not many of these people may be drowned before they reach higher ground to the east or west there will be destitution among them for they will have little time to move their chattels even though the flow is shallow during June. Likely the deaths by drowning will not exceed 50,000 people.

This flood seems to have been caused by military forces purposely breaching the dikes, for during June the dikes in the Kaifeng and Chengchow region cannot well be overtopped. Neither can these breaks be charged to neglect. The dikes in that region have been well maintained for years to protect Kaifeng in particular and have not given away since 1887-88 when they were broken at a high stage of the river. It would seem that only by blasting these dikes could a breach such as is reported be made in them in early or mid-June.

Damage to land

The reports as to the damage to lands by a cover of fine sand from the Yellow River bed being deposited in the area east of Chengchow are exaggerations, no doubt. The flood of 1887-88 did bring much sand to this same area and the land was damaged. But that was under conditions of extreme flood flow. While more and more fine sand will come to this area which already is semi-sterile, the land has not had great value for most crops in recent years. Observations made by me after the 1935 flood prove that in these disasters the damage done by sand coming onto fertile fields and making them less productive is far outweighed by benefits to other lands where the fine, fertile loess soil is spread over much wider areas as a fertilizing agent. In all of these floods where the flow is swift and the break is wide enough so that most or all of the river's flow leaves its regular course and starts cross-country, fine sand deposits follow the middle channel of this wandering flow. In past history the Chinese have looked upon such floods as far more beneficial than detrimental to the lands of the area flooded.

This flood is doubtless a military measure of great importance to the Chinese army in making transport of tanks and artillery and trucks with supplies very difficult. The water and muddy land will make these impediments to advance of a mechanized army felt for the next six months unless all breaches can be promptly closed. It is not at all probable that these breaches will be closed until late fall or winter if the summer high water of the Yellow River is of even average flood dimensions.

OBITUARY

S. Miller Williams, 85, a construction engineer active for many years in the South and Southwest, with headquarters in Tulsa, Okla., died June 12 in Fort Smith, Ark. He had practiced in Tulsa for the past 25 years.

Charles MacGreery, 78, a civil engineer in the Canadian hydrographic department, died June 12.

Kenneth G. Strathy, an engineer for the Dominion Bridge Co., died recently in Lachine, Que., at the age of 54.

Henry H. Fernald, a construction engineer who practiced in western Canada, died recently in Welland, Ont., at the age of 74.

William B. Langenmeim, 66, bridge and construction engineer formerly associated with Joseph B. Strauss, died May 31 at Carlsbad, Calif., where he had lived since his retirement from active practice in 1936. A graduate of the University of Cincinnati, Langenmeim was connected with the construction of the viaducts on the Key West extension of the Florida East Coast Ry. in 1911-1913.

Arthur P. Van Schaick, vice-president in charge of sales of the American Chain & Cable Co., died recently while en route from New Orleans to Chicago at the age of 56.

William C. Hughes, 62, Milwaukee civil engineer and surveyor, died there June 5.

Leon C. Loomis, borough superintendent of construction for the WPA in the Queens Park Department, New York City, died June 13 in New York at the age of 50. Loomis, a graduate in 1912 of Rensselaer Polytechnic Institute, served for four years as an assistant engineer for the New York City Board of Transportation, and during the war was a sergeant with the 302d Engineers. After the war he worked for the Turner Construction Co. and W. F. Chatlos and then went into business for himself as a concrete and foundation contractor. He carried on his contracting business for eleven years before going with the WPA.

Projects Suggested For New York Plan

Regional Plan Association presents projects considered urgent for metropolitan area

To aid the New York City Planning Commission in the task, intrusted to it under the new city charter, of drawing up a master plan for the city, the Regional Plan Association has drawn up a list of major projects which it believes should be incorporated in such a city plan. It has also presented nineteen projects which it considers as especially urgent and requiring immediate attention.

The association's recommendations are drawn up on the basis that the projects in a proper city plan should fit into the outline of a general regional plan for the entire interstate metropolitan region.

The projects proposed by the association are divided into those relating to highway traffic, rapid transit, and parks.

Highway traffic

Basic in the association's metropolitan highway plan is a continuous belt highway, designated as the Metropolitan Loop. This proposed loop would pass through the outer portion of Brooklyn and Queens, cross northern Manhattan, and take a wide swing through the closely settled portions of New Jersey in Hudson and Essex counties. From this loop, a system of radiating highways would move out away from the city to the outer boundaries of the metropolitan region.

Within the loop a series of routes running approximately north and south and east and west would form a roughly rectangular network. It is these inner routes, of course, which would be the major elements in the plan of New York City itself. The association proposes for New York a group of express highways, certain of them open to all traffic and certain restricted to passenger traffic only, which would constitute the New York City portions of the proposed inner routes. In addition, the association presents a group of subordinate routes needed to complete the major thoroughfare system required to handle through traffic.

Rapid transit

The fact that 60 to 70 per cent of railway traffic in New York City is devoted to handling commuters, the association points out, interferes both with the efficiency of through railroad traffic and the convenience of commuters. To remedy this situation, development of an independent system of rapid transit for commutation is recommended. In some cases this independent system would use the same rights-of-way or even the same tracks as the trunk-line railroads; in others they would be over new rights-of-way.

The proposed system consists of a series of radial and connecting routes tied in with an interstate loop between New York and New Jersey and a new Hudson River crossing via the George Washington bridge. The most urgent need, it is asserted, is to tap the New Jersey railroads and bring passengers directly to the central and downtown sections of Manhattan. As a first step to this end, extension of the existing Hudson and Manhattan R. R. northward is proposed with the addition of a new northern crossing under the Hudson; as a second step, development is proposed of an interstate loop connecting Manhattan and New Jersey at the southern tip of Manhattan, running up through Manhattan into the Bronx to connect with the main line of the New York Central R. R.

For the trunk line railroads, the association proposes an outer belt line loop surrounding the congested metropolitan area. Within this would be three interconnected belts, one more or less circling Manhattan, the second within the boroughs of Brooklyn and Queens, and the third connecting New Jersey, Manhattan, Brooklyn and Richmond.

Park areas

The association speaks highly of the work being done by the present New York City Park Commission in developing new parks, but recommends that more land be acquired now for future development as parks. A list is presented of various areas which it is felt ought to be acquired in the near future.

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Cost of TVA Dams Is Allocated

Continued from page 859

investment allocated to navigation and flood control within 30 years.

The financial policy committee that prepared the report consisted of E. L. Kohler, comptroller; T. B. Parker, chief engineer; S. M. Woodward, chief water control planning engineer; W. C. Fitts, solicitor; J. A. Krug, chief power planning engineer; Paul W. Ager, chief budget officer.

CALENDAR OF MEETINGS

NATIONAL SOCIETIES

American Society for Testing Materials, annual meeting, Chalfonte-Haddon Hall, Atlantic City, June 27-July 1.

Society for the Promotion of Engineering Education, annual meeting, Texas A. & M. College, College Station, Texas, June 27-30.

American Society of Civil Engineers, annual convention, Hotel Utah, Salt Lake City, July 20-22.

American Institute of Electrical Engineers, Pacific Coast convention, Portland, Aug. 9-12.

LOCAL AND REGIONAL

Western Association of State Highway Officials, annual convention, Reno, Nev., Aug. 10-13.

American Water Works Association, Central States Section, Hotel Windsor, Wheeling, W. Va., Aug. 17-19.

ELECTIONS AND ACTIVITIES

Architects of North Carolina met in Winston-Salem June 4 to organize the North Carolina Association of Architects. Officers elected were H. R. Weeks, president; Eric G. Flannagan, vice-president; Lucian J. Dale, secretary-treasurer.

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License Examination

The Oregon state board of engineering Examiners will hold an examination for registration of professional engineers July 8-9 in Portland.

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New York City Asks Bids On Two Sections of Subway

The Board of Transportation, New York City, has asked for both separate and combination bids for two new sections of the Independent Subway System. One section will extend from Fulton Street and Pennsylvania Avenue to Bradford Street, Brooklyn, and the other section will run from Bradford Street to Ashford Street, also in Brooklyn.

DISTRIBUTION OF COST OF TVA DAM

PURPOSE	SINGLE-PURPOSE INVESTMENT	JOINT INVESTMENT Amount	JOINT INVESTMENT Per Cent	TOTAL INVESTMENT Amount	TOTAL INVESTMENT Per Cent
Flood Control	$2,600,000	$15,870,627	25	$18,470,627	20
Navigation	4,075,988	22,218,877	35	26,294,865	28
Power	23,967,177	25,393,002	40	49,360,179	52
	$30,643,165	$63,482,506	100	$94,125,671	100

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JUNE 23, 1938

SANITARY ENGINEERS will watch with interest the operating experiences at Lansing's new sewage treatment plant, where city garbage is to be digested with sludge. Laboratory and semi-plant-scale investigations have demonstrated the feasibility of this method of garbage disposal, but its success in practical application to handling the wastes of a large community has not been established. In a sense, therefore, Lansing is pioneering, though on the strength of research and field results both in this country and abroad. Special conditions in Lansing, particularly the manner of collecting garbage, lent themselves to the adoption of a combination plant. The design of the treatment devices (see p. 878) also invites careful attention. It includes the use of a centrifuge for dewatering activated sludge, sludge incineration and by-product gas power equipment, as well as unusual housing facilities. In more ways than one this plant exemplifies recent progress in waste disposal practice.

Plywood Gusset Plates

POPULAR BELIEF to the contrary, most new products do not come into use backed by an extensive fund of research knowledge. Or if their promoters have been so forehanded, someone promptly adapts the product to a new field of use. Thus practice and knowledge often see-saw back and forth, first one and then the other being in the lead. Early research on plywood, for example, was centered on other uses than for gusset plates in timber trusses, and practice ran ahead of research when the new material was applied to this service. Various questions of efficiency and safety were left unanswered. Research has recently sought to remedy this situation, and in last week's issue and again this week some of the results of two different investigations are reported. Strength is seen to be greatly affected by the direction of the applied load relative to the grain of the outer plies. Optimum tension and compression values occur when load application is in one direction, best shear resistance when it is in another direction. Shear values of the glued joints have a controlling influence. Trusses designed in the future will benefit from the research and in addition their designs may suggest new subjects for study.

Questioning a Tradition

WHEN HIGHWAY LOCATION rose to the status of a definite technical art it took over from railroad practice the traditional doctrine that curves must be spiraled. The tacit assumption was made that vehicles on road and rail act in the same way in passing around curves and require the same provisions in the roadbed. In due course the practice was extended, and it has gone so far that some of the newest road curves seem to vary in sharpness throughout, the easements leaving little or nothing of the central curve. The result is that the driver must shift his wheel continuously; he is under greater strain as to both attention and effort—an undesirable effect. Is it good practice to carry the easement tradition thus far? Is it not better to leave highway curves unspiraled than to complicate the driving task? The curving action of highway vehicles is far from being identical with that of railroad curves, and this fact raises obvious question as to the proper extent of spiraling. If there is evidence that spiraled curves are either smoother or safer than simple curves it ought to be put on record.

Delta-Plain Floods

FLOODS that result from water falling on the slopes of stream valleys and gathering in the channel follow a familiar pattern and are subject to well known means of prevention and control. Very different phenomena occur where mountain torrents debouch suddenly on flat delta plains. The flood hazards are greater and more widely distributed, and methods of control are less well established. It is this condition that has made the flood problem of Los Angeles County so constant a matter of study for decades past and that attracts interest to the closely related problem of Orange County, directly adjacent. The outline of conditions given in this issue will be found important by engineers concerned with flood problems anywhere, especially because storage or detention in headwater reservoirs has recently come under a heavy cloud of doubt. Last year's flood experience indicates that reservoir control may be seriously jeopardized by debris accumulation, and if this indication is confirmed by fuller study channel regulation and enlargement will have to be the main reliance. At present it appears certain that the flood problem of the Los Angeles coastal plain will long be a major engineering issue, the more so because of the assumption of flood responsibility by the federal government. Should another big flood visit the region soon the government may find itself confronted by a bill of substantial size.

An Unjust Burden

CONSTRUCTION is already paying more than its share in unemployment relief taxes, but it will be subject to added discrimination if the proposed merit-and-debit-rating is adopted as a basis for computing the unemployment tax rate. The proposal would penalize the industry by a high tax rate because of its inability to provide continuous employment. Already in effect in Wisconsin and scheduled for adoption by several other states, this rating system is thoroughly unjust.

Because construction employment is in the main intermittent and seasonal, wage rates are high. The excess hourly rate paid by construction as compared with those paid in manufacturing industries is in itself an unemployment tax. But with the recent advent of social security and unemployment "insurance" taxes, a further charge was laid on construction, and this tax, however just in essential purpose, was discriminatory against construction in its effect, since it was based on payroll rates which already contained an "unemployment insurance" equivalent. Under these circumstances there can be no possible excuse for assessing a further penalty by an increased unemployment tax rate on the score of inability to provide continuous employment.

Penalty rates are used in the case of compensation insurance, and not improperly so, for here it is possible to bring down the rate by reducing the accident hazard. In the case of the unemployment levy, however, the industry should not be placed under penalty, since it is powerless to correct the trouble. It happens also that state and national legislation is itself largely responsible for reducing the continuity of employment in construction. Practically all public construction, and through union influence much private construction as well, must now obtain its labor supply from local sources. In consequence the possibility of carrying a worker over from one job to another on a different site is practically eliminated. Even though a contractor may have continuous work on a number of different jobs he cannot give his men continuous employment beyond the length of the local job. Yet because of this very condition, itself the result of governmental dictation, his work is now to be made subject to penalty.

All the facts of the situation argue that construction should be exempt from any debit-rating increment on its unemployment tax. To bring this fact to public attention, however, and to present it with convincing force, will require a vigorous campaign in each state by those interested in construction.

In the last analysis it is the general public itself that must pay for excessive construction costs, and therefore it is the public that suffers from unjust levies on construction. When the citizen body comes to realize the injustice and harmful nature of the proposed rating plan it can be depended on to guide its state legislatures to the proper action.

TVA Cost Allocations

THE long anticipated allocation of the cost of TVA dams to navigation, flood-control and power has been announced. Navigation is assigned 28 per cent of the total cost of the three completed dams (Norris, Wheeler and Wilson), flood control 20 per cent, and power 52 per cent.

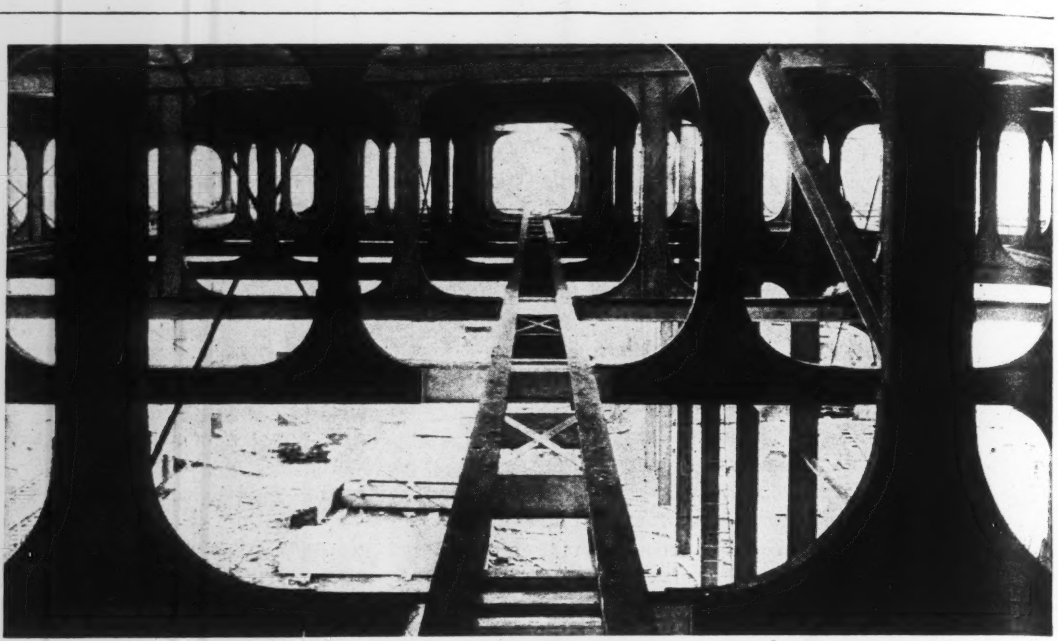
At each project the full cost of such facilities as locks and powerhouses was charged to navigation or power, as the case may be; common costs such as the dam and reservoir were distributed on the following basis: navigation 35 per cent, flood control 25, and power 40 per cent of the total common costs of the three projects. No one single method of allocating these common costs was adopted, but greatest weight was given to the "alternative-justifiable-expenditure theory", using estimates of the cost of developing each of the three services singly to determine ratios for splitting up the total actual cost.

The method used is eminently fair in principle, though some may question the details of its application—such as omitting interest during construction. With the TVA Act as background the committee that made the allocation could not have been accused of inconsistency if it had accepted the fiction that power is a by-product and had charged most of the common costs to navigation and flood control. For having resisted the temptation to arrive at low rates by this route the committee is to be congratulated.

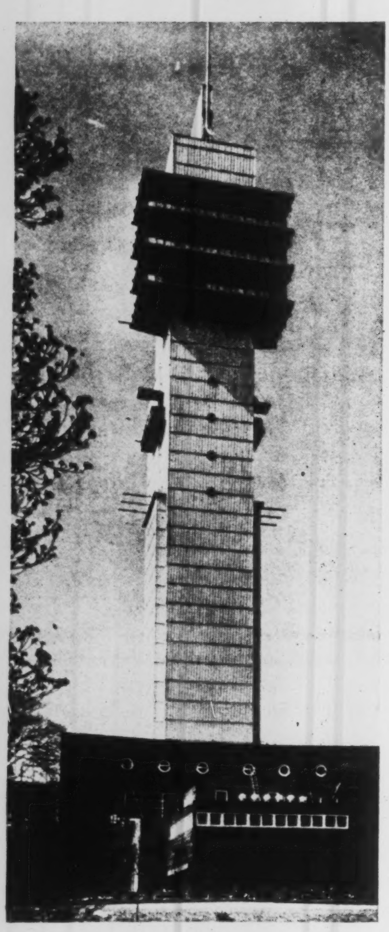
Looking backward, it is of interest to speculate whether publication of these figures now, after long and needless delay, was not forced by Arthur Morgan's exposure of the conflict within the TVA board. If imminence of the Congressional hearing that he called for is responsible for the publication of the allocation figures, then his hand still has an important part in directing the destinies of the TVA experiment.

Allocation of capital costs, however, is but one step in reaching a power rate. Its fairness may be largely offset by improper allocation of operating and promotional costs and by failure to provide for development costs. Finally, it would be well at this stage to make public facts as to how these capital costs check with the assumed capital costs that were used in fixing TVA power rates announced before the cost of Norris and Wheeler dams was known. All have a bearing on the mythical "yardstick" rate about which so much is heard. At best it will be a subsidized rate; how much it is subsidized should be a matter of public record.

PICTURES IN THE NEWS



VIERENDEEL TRUSS INVADES THE BUILDING FIELD. Designed to accommodate conveyors running on the track supports shown in the center, these trusses are the outstanding feature of a welded fertilizer plant built by The Austin Co. for International Agricultural Corp. at Chicago Heights, Ill. Tracks have been installed in four of the twelve 7-ft. panels.



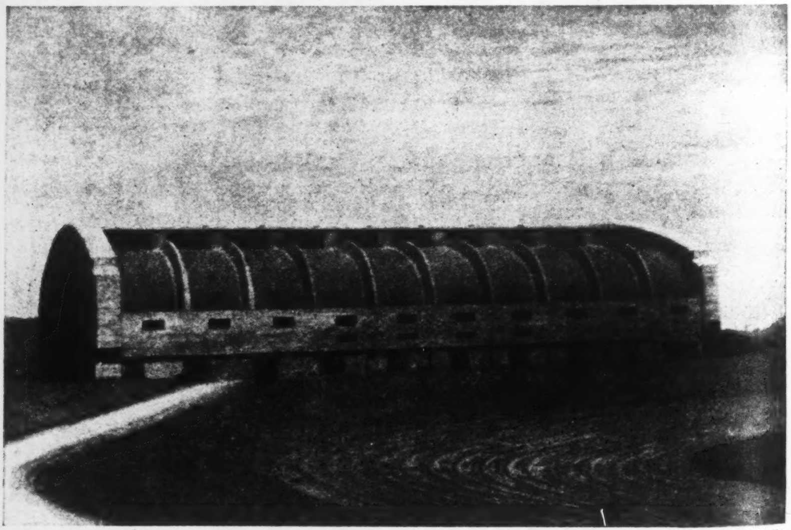


Photo by Lewis Ellis

TAIT'S TOWER at Glasgow's Empire Exposition (left) is 280 ft. high and the tallest covered building in the United Kingdom. Construction consists of a steel framework sheathed in sheet metal. Equipped with elevators, the building serves as an observation tower.

*RIDGES covering outside roof trusses are a striking feature of the recently completed California live stock exposition building just outside the San Francisco city limits (*ENR *Feb. 3, 1938, p. 173). A partly completed race track is seen in the foreground.*

Basic Principles of Soil-Cement Mixtures

FRANK T. SHEETS* AND MILES D. CATTON

President, Portland Cement Association, Chicago, and Member, Development Department, Portland Cement Association, Chicago

Laboratory studies uncover basic principles for producing consistent, predictable results in processing soil-cement mixtures for light traffic roads

Processing soils with cement to increase their stability is not a new thought; it has however gained new importance with the need for using local soils, fixed or stabilized by admixtures, as bases for carpet surfaces if durable low-cost all-season roads are to be widely provided. It was foreseen that if cement is to have a sound claim to a place in soil treatment it must be known how various soils responded to cement action and how the processing should be conducted. The answers called for fundamental research. The article that follows is a report of the results to date of that research and is outstanding among recent studies in soil stabilization. —EDITOR

BASIC PRINCIPLES governing the use of soil-cement mixtures for light traffic road use can be laid down as a result of laboratory research started by the Development Department of the Portland Cement Association in January, 1935, and still in progress. Applying these principles to the soils investigated, the engineer can produce consistent, predictable results.

Prior to the laboratory determinations that are described here and the recent field experiences that will be described in a second article, various tentative trials at treating soils with cement had been undertaken with hopes of producing low-cost, light-traffic roads or of improving the performance of subgrades under pavements. Of especial significance was the pioneer work of the South Carolina state highway department in soil-cement mixtures. This was initiated in 1932 by Charles H. Moorefield, former state highway engineer, under the direction of W. H. Mills, Jr., testing engineering for the state highway department (*ENR*, Nov. 23, 1935.) While the results of this early work were far from perfect, they were nevertheless most challenging.

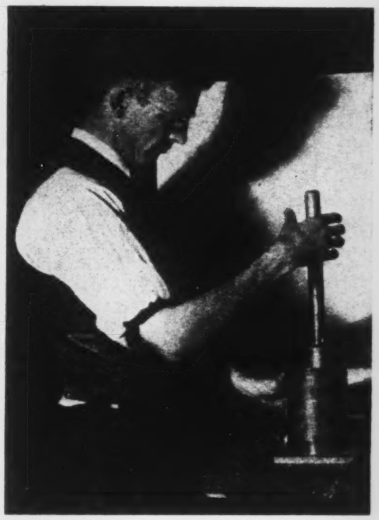


Fig. 1. Proctor equipment for compacting soil samples by hand.

In taking up the advanced study a thorough study was first made of all technical literature on soils, including soil physics, mechanics and chemistry. This was supplemented by a review of the South Carolina work and some exploratory tests of the United States Bureau of Public Roads. This general survey indicated that there were possibilities of combining soil and cement to produce a low-cost, all-weather road for use in the light-traffic road field provided the relations of soil and cement could be evaluated and such work removed from a cut-and-try or hit-and-miss process.

In the review of soil knowledge, the work of R. R. Proctor was outstanding in that he brought to national attention the principle that a direct relation exists between the moisture content of a soil, the degree of compaction and the resulting density. (*ENR*, Aug. 31, Sept. 7, 21 and 28, 1933). These principles were uncovered by the materials and research division of the California state highway commission.

Proctor found that the compaction of soil in the field obtained by a sheepsfoot roller could be duplicated in the laboratory by packing three successive layers of the same soil about 1½ in. thick in a cylinder with a 5½ lb. rammer; each layer to be packed by 25 uniformly distributed blows of the rammer dropping free through a distance of 12 in. He used this laboratory method for determining the optimum or desirable moisture content which will produce maximum density or stability in the field when using sheepsfoot rollers for compaction. He also showed that any selected density for a given soil can be obtained repeatedly by duplicating the required moisture content and compacting procedure. The Proctor laboratory equipment is shown in Fig. 1; a machine to remove the personal element (Fig. 2) is now used in our laboratory work.

It was anticipated that soil-cement mixtures so prepared would not only have the stability of natural soils when compacted to maximum possible density, but that the presence of the cement would impart additional stability.

With the adoption of these concepts it was obvious that an exploratory investigation of soils and soil-cement mixtures would resolve itself into:

1. A laboratory investigation of various soils to determine the influence of cement;
2. A field investigation to determine the practicability of applying laboratory findings.

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* This study was inaugurated and carried forward practically to completion during the period in which Mr. Sheets served as consulting engineer and director of the Development Department of the Portland Cement Assn.

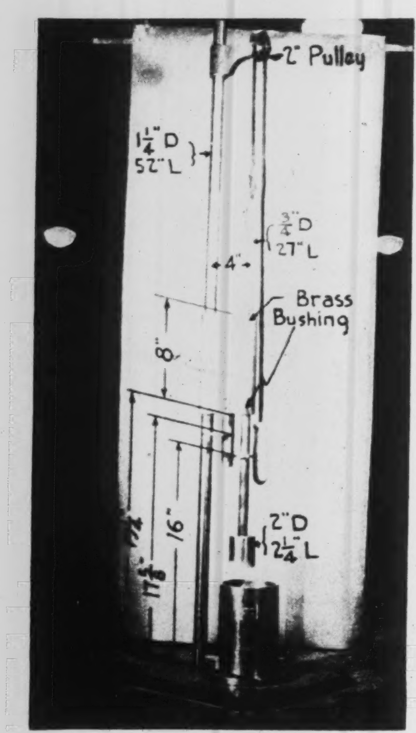


Fig. 2. **Proctor soil compacting device arranged to eliminate the personal element.**

A laboratory research project was outlined for developing needed data for a wide range of soils. A 1½-mi. cooperative field project was set up near Johnsonville by the South Carolina state highway department, the U. S. Bureau of Public Roads and the Portland Cement Association. This project was built late in the fall of 1935 under the supervision of the highway department and M. D. Catton by applying the results of laboratory tests on the soil made by the highway department and the association, which followed the basic concepts and laboratory procedures outlined in this report. Gratifying results were obtained which have been reported by W. H. Mills, Jr., testing engineer of the highway department (*ENR*, Dec. 3, 1936). A critical inspection of this project on April 7, 1938, revealed it to be in fine condition.

Tests undertaken

The purpose of the laboratory-research project was to determine the relative stability and durability of a wide range of raw soils and soil-cement mixtures, compacted to maximum density at their optimum moisture content, when exposed to weathering agencies; to establish basic principles involved in the physical-chemical relations of soil-cement mixtures; to determine the relative adaptability of soils found throughout the United States to successful treatment with portland cement under prevailing climatic conditions, and to indicate field construction requirements. The tests follow:

Series 1—Selection of all representative soil types from various parts of the United States and the determination of their physical test constants and grain size. The soils selected for testing are given in Table I, together with their identification. The laboratory sample numbers shown in this table are used throughout the report to identify the soils.

Series 2—Determination of moisture-density relations of raw soils by varying the moisture content and using standard Proctor method of compaction.

Series 3—Determination of influence of various percentages of portland cement on moisture-density relations of soil-cement mixtures by varying the moisture content and using standard Proctor method of compaction. Determinations of the resistance of the resulting specimens to the Proctor penetration apparatus were also made but have since been abandoned as no readings could be obtained after the soil-cement specimens were compacted or had hardened for a few hours.

Series 4—Determination of influence of variable cement contents on the durability and stability of soil-cement mixtures by obtaining weight of material lost upon repeated cycles of wetting and drying of cylinders compacted at optimum moisture by standard Proctor method.

Series 5—Same as Series 4, using moisture changes, volume changes and weight of material lost in repeated cycles of freezing and thawing of cylinders as a criterion of the influence of added cement upon the durability and stability of soil-cement mixtures.

Test procedures

The physical test constants and grain size of soils were determined by the Bureau of Public Roads according to its standard procedures and the results are given in Table II. The moisture-density relations of soils and soil-cement mixtures were determined by the Proctor method previously described. Fig. 3 shows the moisture-density relations of a fine sandy loam top soil. This type curve is typical of many soils.

Specimens of raw soil and various soil-cement mixtures were molded at optimum moisture using the standard Proctor method of compaction. They were then removed from the mold and exposed to laboratory air for seven days before subjecting them to the severe durability tests. The test data soon proved that cement hydration plays a very important role in hardening soil-cement mixtures so this seven days' air drying has since been changed to seven days' exposure to an atmosphere of high humidity to permit the cement to hydrate in a normal manner and this also more nearly parallels field conditions where the newly constructed roadway has a damp cover of earth, straw or hay.

Originally, after 7 days' air drying, two specimens of each mixture were placed in an oven at 160 deg. F. for 42 hr. After this period of about nine days' drying, the specimens were ready for wetting and drying test. As soon as the specimens had been weighed and measured after removal from the oven, they were immersed in tap water for 5 hr., removed and again weighed and measured. (This now takes place immediately after the seven-day period of hydration in moist air.) One set of specimens was then vigorously wire brushed to remove loose material and establish soil loss. The wetting and drying constituted one cycle which was continued for at least twelve cycles or until measurements were no longer of value.

Table I — IDENTIFICATION OF SOILS TESTED

Lab. No.	Soil Group, U. S. Bu. of P. R. Classification	Source	Description
2a	A-2	South Carolina	Fine sandy loam top-soil
3a	A-3	San Joaquin Co., California	Fine sand topsoil
4a	A-4	Calloway Co., Missouri	Silty clay loam subsoil
5a	A-5	Minnesota	Clay subsoil
5c	A-5	Maryland	Micaceous sandy loam top-soil
5d	A-4	Latah Co., Idaho	Heavy silt loam top-soil
6a	A-6	Pike Co., Missouri	Clay subsoil
6b	A-7-6	Fairfax Co., Virginia	Clay subsoil
6c	A-6	Guadalupe Co., Texas	Clay subsoil
6d	A-6	San Joaquin Co., California	Clay (adobe) top-soil
7a	A-4	Franklin Co., Kansas	Light silty clay subsoil
7b	A-6-7	Michigan	Clay subsoil
7c	A-7-6	Pike Co., Missouri	Clay subsoil
7d	A-7	Hinds Co., Mississippi	Clay subsoil
7e	A-7	Hinds Co., Mississippi	Clay (Sharkey) subsoil
7f	A-7-4	Sangamon Co., Illinois	Light silty clay loam top-soil (Bates Road)
8a	A-8	Minnesota	Peaty muck (silt loam) top-soil

After 7 days' air drying two other specimens of each mixture were placed on felt pads in the moist room for 5 to 7 days to permit complete capillary absorption of moisture. Measurements of weight and volume were made daily. After this initial 12- to 14-day preparation period, the specimens were ready for repeated freezing and thawing. (They are now started on this test after a seven-day period of hydration in moist air.)

The specimens were placed on special carriers, illustrated in Fig. 4, in a refrigerator capable of freezing to the center of the specimens in about 3 hr. and lowering the temperature of the centers to —15 deg. F. in 20 hr. After 20 hr. in the refrigerator, the specimens were removed, weighed, measured and placed on wet felt pads in the moist room to thaw for 24 hr. with free water added to the pads as needed to permit complete capillary absorption of water by the specimens. The specimens were then weighed and measured again. One set of specimens was then vigorously wire brushed to remove loose material and established soil loss.

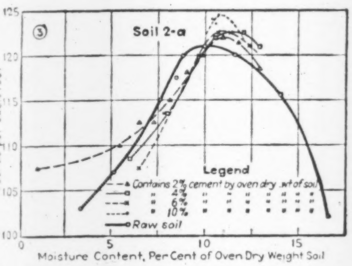


Fig. 3. Example of moisture-density relations of raw soil and soil cement mixtures compacted by standard Proctor method.

This constituted one alternation of freezing and thawing. All specimens were subjected to at least twelve cycles or until measurements were no longer of value.

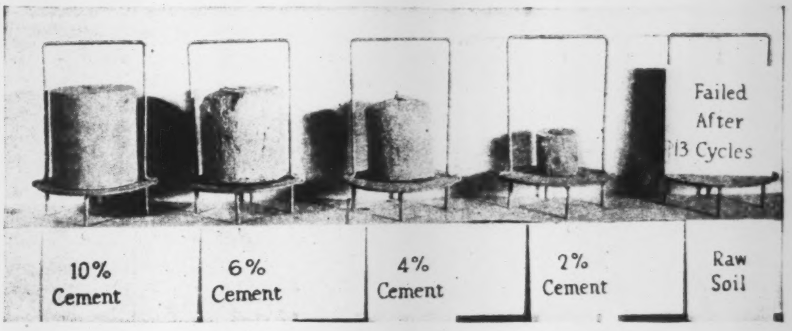


Fig. 4. Appearance of soil sample (2a) after 20 cycles of freezing and thawing.

Each of these series of tests gave the information for which it was designed. It is now seen that the influence of adding cement to soil shown by one test series serves to substantiate similar results shown by the other test series. In other instances, a correlation of the data from one test series with that of another makes it possible to draw certain conclusions which could not be deduced from one test series alone. And, finally, the results from all of these test series served as a background for the theoretical analysis of the basic relations governing soil-cement mixtures.

Series 3, definitely proved that soil-cement mixtures, before cement hydration, have moisture-density relations similar to those for raw soil but the variations in density due to variations in cement content were not comparable to variations in durabilities and hence cannot be used as a criterion for desirable cement contents to use to produce desirable durability. Durability tests of Test Series 4 and 5, however, gave results that reveal definitely the influence of cement on the durability of soil-cement mixtures, and can be used directly as a criterion for the most desirable quantity of cement to be added to a soil to produce a stable roadway.

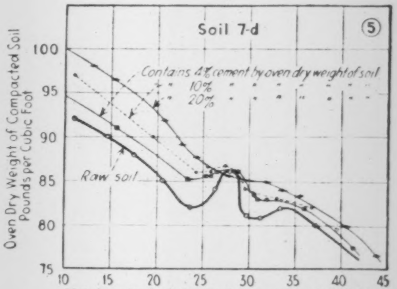


Fig. 5. Moisture-density curve for soil 7d, a Mississippi clay.

In analyzing the test data it has been helpful to divide the soils into three general treatment groups based upon the test results obtained from Series 4 and 5. A summary of these data is given in Table III. Soils showing a very marked hardening with the addition of cement were placed in Treatment Group I, soils showing marked hardening with the addition of cement were placed in Treatment Group II, soils showing substantial hardening with the addition of a reasonable amount of ce-

TABLE II — PHYSICAL TEST CONSTANTS AND GRAIN SIZE OF SOILS

Lab. Sample No.	Optimum Moisture Per Cent	Liquid Limit (L.L.)	Plastic Limit (P.L.)	Plastic Index (P.I.)	Shrinkage Limit (S.L.)	Shrinkage Ratio (S.R.)	Centrifuge Moisture Equivalent (C.M.E.)	Field Moisture Equivalent (F.M.E.)	Sand, Above 0.05 mm.	Silt, mm. .05-.005	Colloids & Clay .005-000 mm.	Colloids Below .001 mm. (1)	Specific Gravity
2a	10	19	17	2	15	1.8	10	18	77	1	22	15	2.662
3a	11	18	......	......	28	1.5	7	23	88	1	11	7	2.690
4a	16	30	23	7	20	1.7	28	25	7	69	24	10	2.683
5a	31	65	35	30	31	1.5	49	43	6	24	70	17	2.647
5c	17	36	33	3	30	1.5	19	35	61	23	16	10	2.732
5d	16	32	25	7	22	1.7	26	28	16	66	18	8	2.647
6a	20	58	22	36	13	1.9	34	28	23	28	49	32	2.680
6b	20	62	29	33	13	1.9	40	39	23	35	42	24	2.815
6c	22	61	23	38	10	2.1	39	34	10	43	47	20	2.720
6d	19	48	20	28	10	2.0	31	28	14	48	38	18	2.696
7a	17	35	21	14	16	1.8	25	21	14	56	30	13	2.635
7b	18	44	24	20	18	1.8	52*	23	5	19	76	32	2.727
7d	20	60	27	33	14	1.9	39	34	11	43	46	29	2.711
7a	28	118	35	83	14	1.9	98*	50	14	18	68	**	2.761
7e	22	67	22	45	12	1.9	58*	32	32	16	52	28	2.721
7f	21	46	29	17	20	1.7	31	29	20	60	20	10	2.597
8a	81	170	......	......	66	0.8	92	244	10	80	10	7	2.070

(1) Also included in clay fraction. * water logged. ** flocculated.

ment were placed in Treatment Group III. Work on soils 6b, 6c, 7c, 7d, 7e and 8a, unusually bad subsoils of limited occurrence has not been completed. The moisture-density curves of these soils have different characteristics than the curves for the other soils and considerably more laboratory work is involved in their evaluation. Fig. 5, of soil 7d, Mississippi clay, is a notable example of these irregular type curves. In subsequent discussions, these soils on which tests have not been completed have been placed together in a Group IV.

The following discussion relative to these treatment groups is based on cement addition expressed as a percentage of the dry weight of the soil which is in accordance with the control methods used in the laboratory. The influence of cement can be evaluated most accurately on a volume basis since this will place a constant amount of cement in each unit volume of compacted soil regardless of its weight or other characteristics. The data now available in this report supply the information needed to add cement on an apparent volume basis. This procedure has been followed on all subsequent work with volumes converted to equivalent weight for actual laboratory control by considering 1 cu. ft. of cement as weighing 94 lb. The differences in weight and volume proportions of cement for various soils are given in Table IV.

Results by groups

The soils falling in Group I, sandy soils, give outstanding beneficial results from small quantities of added cement. These are soils 2a, 3a, and 5c (U.S.B.P.R. soil classes A-2, A-3 and A-5). Fig. 6 shows typical results of the soil losses in the wetting-drying tests and Figs. 8 and 7 show typical results of the soil losses in the freezing-thawing tests. The 6 per cent cement specimens give outstanding results. Volume and moisture changes in these soils with repeated freezing and thawing are insignificant with 2 per cent cement added. Figs. 9 and 10 show typical results.

Soils of Group II, 4a, 5d, 7a (U.S. B.P.R. soil class. A-4), and 7f (U.S.B.P.R. soil class A-7-4), are of a silty character and were decidedly hardened with an addition of 6 per cent cement, although 10 per cent was necessary to reduce effectively slaking losses, freezing - thawing weight losses, moisture changes and

TABLE III — GENERAL SUMMARY INTO TREATMENT GROUPS OF RESULTS FROM DURABILITY TESTS

	Treatment GROUP I				Treatment GROUP II				Treatment GROUP III			
	Very marked hardening with added cement. High resistance to (1) wetting and drying and (2) freezing and thawing.				Marked hardening with added cement. Good resistance to (1) wetting and drying and (2) freezing and thawing.				Substantial hardening with reasonable cement content. Substantial resistance to (1) wetting and drying and (2) freezing and thawing with reasonable cement content.			
Soil Characteristics	Soil Lab. No.	U.S.B.P.R. Soil Class	Description	Test Values	Soil Lab. No.	U.S.B.P.R. Soil Class	Description	Test Values	Soil Lab. No.	U.S.B.P.R. Soil Class	Description	Test Values
Liquid Limit	2a	A-2	S. C. fine sandy loam	19	4a	A-4	Mo. silty clay loam	30	5a	A-5	Minn. clay	65
	3a	A-3	Calif. fine sand	18	5d	A-4	Idaho heavy silt loam	32	6a	A-6	Mo. clay	58
	5c	A-5	Md. micaceous sandy loam	36	7a	A-4	Kans. light silt loam	35	6d	A-6	Calif. adobe	48
					7f	A-7-4	Ill. silty clay loam	46	7b*	A-6-7	Mich. clay	44
Plasticity Index	2a	A-2	S. C. fine sandy loam	2	4a	A-4	Mo. silty clay loam	7	5a	A-5	Minn. clay	30
	3a	A-3	Calif. fine sand	..	5d	A-4	Idaho heavy silt loam	7	6a	A-6	Mo. clay	36
	5c	A-5	Md. micaceous sandy loam	3	7a	A-4	Kans. light silt loam	14	6d	A-6	Calif. adobe	28
					7f	A-7-4	Ill. silty clay loam	17	7b*	A-6-7	Mich. clay	20
Clay Content	2a	A-2	S. C. fine sandy loam	22	4a	A-4	Mo. silty clay loam	24	5a	A-5	Minn. clay	70
	3a	A-3	Calif. fine sand	11	5d	A-4	Idaho heavy silt loam	18	6a	A-6	Mo. clay	40
	5c	A-5	Md. micaceous sandy loam	16	7a	A-4	Kans. light silt loam	30	6d	A-6	Calif. adobe	38
					7f	A-7-4	Ill. silty clay loam	20	7b*	A-6-7	Mich. clay	70
Per Cent Solids at Maximum Density	2a	A-2	S. C. fine sandy loam	73	4a	A-4	Mo. silty clay loam	66	5a	A-5	Minn. clay	53
	3a	A-3	Calif. fine sand	65	5d	A-4	Idaho heavy silt loam	65	6a	A-6	Mo. clay	63
	5c	A-5	Md. micaceous sandy loam	63	7a	A-4	Kans. light silt loam	66	6d	A-6	Calif. adobe	63
					7f	A-7-4	Ill. silty clay loam	60	7b*	A-6-7	Mich. clay	64
Nature of Proctor Curve	2a	A-2	S. C. fine sandy loam	Regular	4a	A-4	Mo. silty clay loam	Regular	5a	A-5	Minn. clay	Regular
	3a	A-3	Calif. fine sand	Regular	5d	A-4	Idaho heavy silt loam	Regular	6a	A-6	Mo. clay	Regular-Irregular
	5c	A-5	Md. micaceous sandy loam	Regular	7a	A-4	Kans. light silt loam	Regular	6d	A-6	Calif. adobe	Regular
					7f	A-7-4	Ill. silty clay loam	Regular	7b*	A-6-7	Mich. clay	Regular

* Soil 7b, Michigan clay subsoil, almost falls in Treatment GROUP II. The characteristics of soils in Treatment GROUP II predominate and additional testing may identify it definitely with this group.

TABLE IV — CEMENT CONTENT BY VOLUME OF SOIL-CEMENT MIXTURES
Compacted at Optimum Moisture Content Corresponding to Cement Content by Oven-Dry Weight of Soil-Cement Mixtures Compacted at Optimum Moisture Content

Soil		2% cement by oven dry weight of soil	4% cement by oven dry weight of soil	6% cement by oven dry weight of soil	10% cement by oven dry weight of soil	15% cement by oven dry weight of soil	20% cement by oven dry weight of soil
Lab. No.	Class						
2a	A-2	2.54	5.01	7.40	12.03	......	......
3a	A-3	2.37	4.63	6.81	11.17		......
4a	A-4	2.26	4.46	6.52	10.56		......
5a	A-5	1.86	3.60	5.32	8.63		
5c	A-5	2.28	4.47	6.63	10.64	......	......
5d	A-4	2.19	4.17	6.09	9.77	......	
6a	A-6	......	4.21	6.32	10.16	14.71	......
6b	A-7-6	......	4.10	5.94	9.67	......	
6c	A-6	......	4.12	6.09	9.96		
6d	A-6	......	4.38	6.47	10.43		
7a	A-4	2.29	4.41	6.56	10.45		
7b	A-6-7	......	4.31	6.38	10.39		......
7c	A-7-6	......	4.06	5.96	9.72		
7d	A-7	......	3.54	......	8.36		15.07
7e	A-7	......	4.13	6.02	10.11		......
7f	A-7-4	1.96	3.85	5.66	8.89	......	......
8a	A-8	......	......	2.53	4.06	......	......

volume changes to a desirable minimum. Figs. 7. 11. 12. 13 and 14 show typical results.

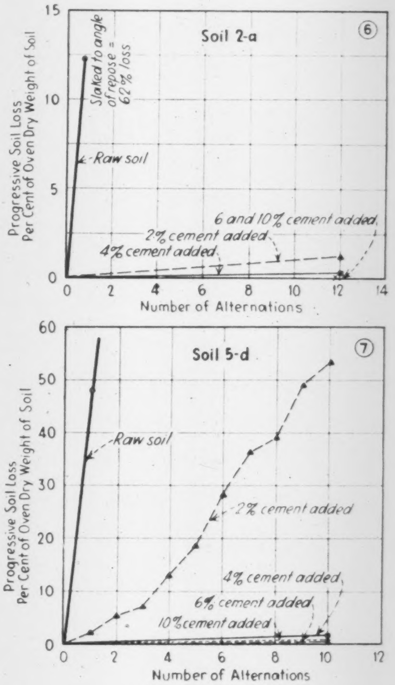
Inasmuch as the durability tests employed in this investigation were quite severe it was anticipated, and field projects are verifying the fact, that soil-cement mixtures passing these tests will have high resistance to natural weathering conditions. In fact. the results are so consistent that definite recommendations can now be made for laboratory analysis to determine treatment specifications and further, recommendations can now be made for field construction methods for projects built of soils within the character range of those represented by Groups I and II as well as Group III discussed below.

Relations between liquid limit, plasticity index and clay content of the soils of these two groups were plotted and are shown in Figs. 15 and 16. It will be noted that the constants for these soils fall together in the lower left hand corner of the charts with liquid limits below 50, plasticity indices below 25 and clay contents below 35 per cent. These data are also summarized in Table III. Relations between other physical test constants were also studied but no consistent relations could be found between them and the durability tests.

The percentage of solids at optimum moisture and the type of moisture-density curve obtained from each soil are also given in Table III. It will be seen that all of the soils falling in Groups I and II possess moisture-density curves of a "regular" character and that the per cent of solids. when compacted at optimum moisture, is 60 or more.

Soils in Group III were hardened appreciably by the addition of about 10 per cent cement which also materially reduced volume and moisture changes and the weight losses in the durability tests. The outer portion of some of the tests specimen became soft and disrupted but the inner core remained firm or hard. Fig. 17 shows the results of the freezing-thawing test on soil 5a.

By referring to the liquid limit, plasticity index and clay content relations for the soils of Group III shown in Figs. 15 and 16 it will be seen there is no simple relation between these constants. The clay contents range between 38 and 76 per cent. Also referring to Table III it will be seen the per cent solids at optimum moisture vary from 53 to 64 and the moisture-density curves are regular or regular-irregular.



Figs. 6, 7. **Graphs showing progressive soil losses of soils due to wetting and drying. Soil 2a is sandy and 5d is silty.**

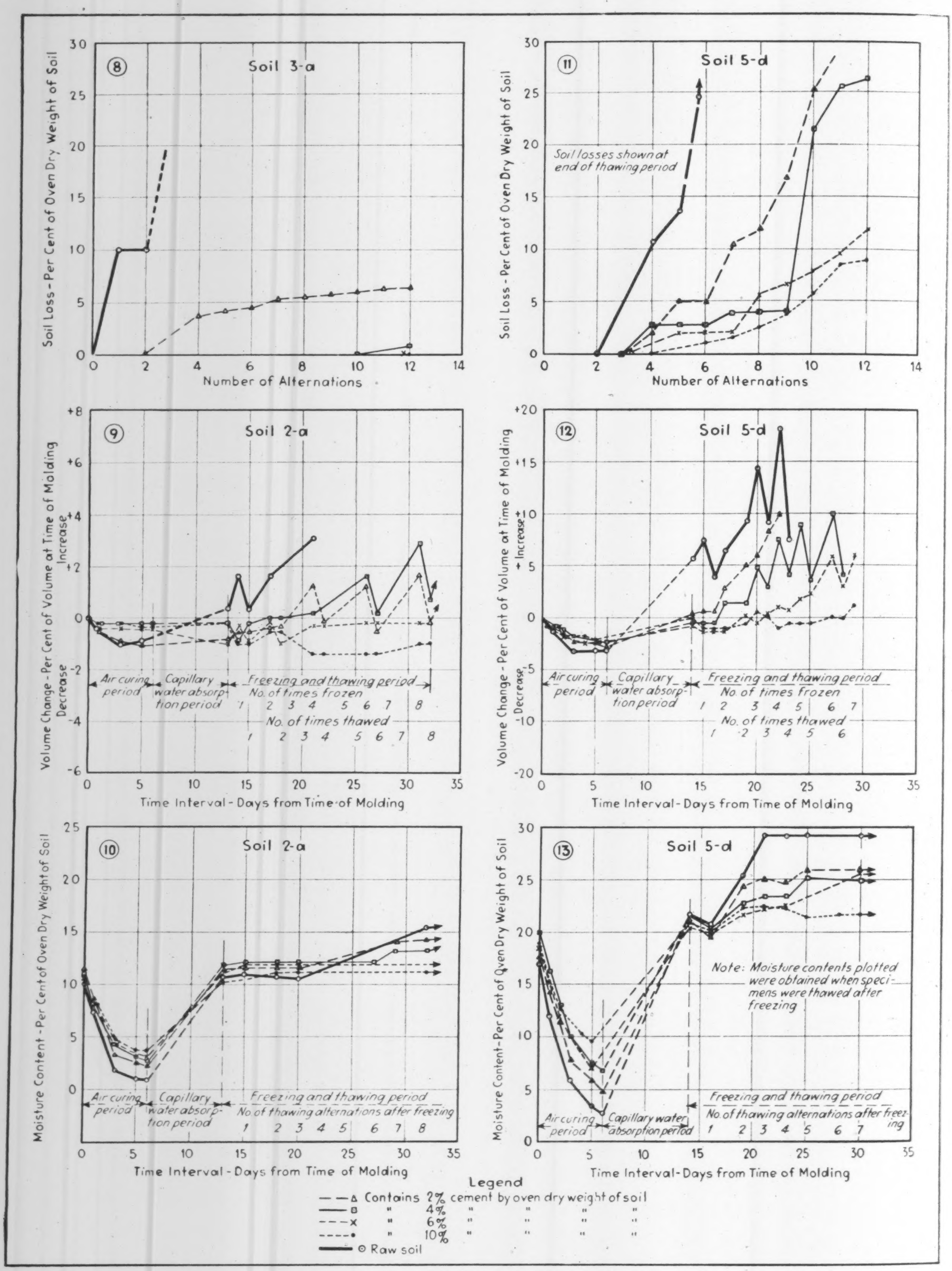
The test results show that these soils, which represent the commonly occurring subsoils of the country. respond very definitely to cement treatments. Laboratory durability tests should be made on any soil having characteristics similar to those in Group III to determine desirable cement contents and to set up other treatment requirements.

As previously mentioned, work on the unusual, bad subsoils of limited occurrence (soils 6b, 6c, 7c. 7d. 7e and 8a) has not been completed. These soils have been placed in a Group IV to permit easy identification. They include soils of high clay and colloidal content, as well as a peaty muck, which were selected so that eventually the entire range of soils would be studied. These soils are shown to be more complex by the nature of the moisture-density curves and hence require considerably more laboratory work to evaluate soil-cement relations. Tests now under way on these soils indicate that successful means of treatment will be evolved.

The influence of cement hydration on durability was mentioned in conjunction with the test procedures. Since cement hydration is one of the major influences producing hardened soil-cement specimens, all subsequent laboratory and field work on soil-cement mixtures has been conducted so as to permit normal cement hydration during a seven-day period.

General conclusion

The foregoing information has been summarized in Table III. A study of this table of soil groupings and test constants, together with the foregoing detailed discussion of each



Figs. 8, 9, 10, 11, 12, 13. Graphs of soil losses and volume changes due to alternate freezing and thawing. Soils 2a and 3a are sandy and soil 5d is of silty character.

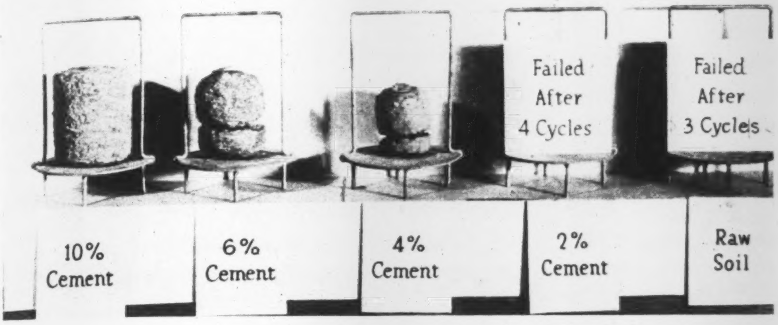


Fig. 14. **Appearance after 12 cycles of freezing and thawing of Kansas light silty clay soil (7a).**

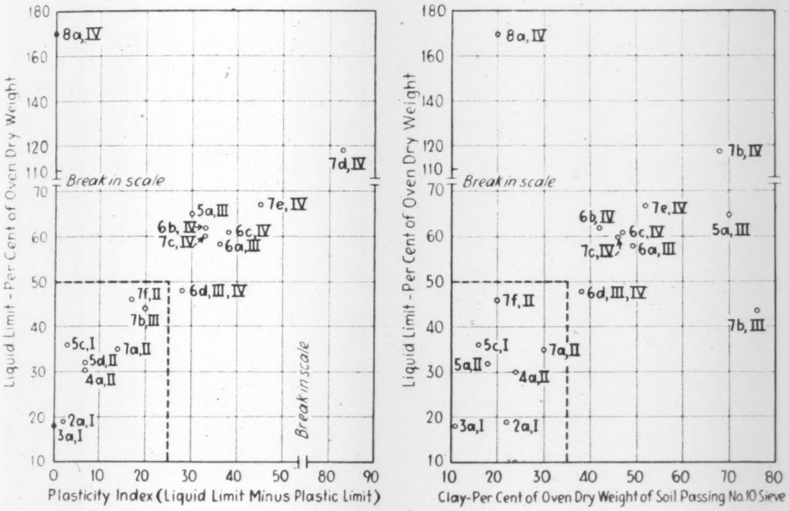


Fig. 15, 16. **Relations between liquid limit, plasticity index and clay content of soils of groups I and II.**

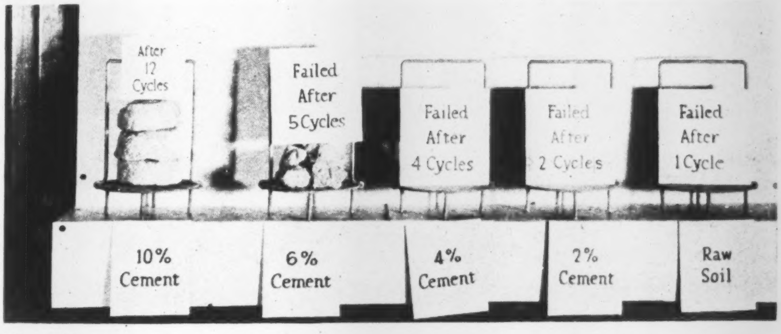


Fig. 17. **Appearance of Minnesota clay soil (5a) after various cycles of freezing and thawing.**

group, shows a direct correlation between the hardening influences of cement on soil-cement mixtures and soil characteristics. As this study is intensified, even more correlation can be found. It is believed that as data of this nature is obtained from other soils and soil-cement mixtures and added to this tabulation, more exact relations will be set up between the hardening influence of cement and soil characteristics and thus permit predetermination of treatment requirements without recourse to detail durability tests.

At the present time, no effort has been made to draw sharp lines between soil characteristics and treatment requirements. However, the following general conclusions are justified regarding characteristics of soils falling in Treatment Group I or II:

1. Liquid limit will be below 50.
2. The plasticity index will be below 25.
3. The clay content will be below 35.
4. The percentage of solids at maximum density will be 60 or greater.
5. The soil will possess a "regular" moisture-density curve.

If a soil meets the above specifications, it can be effectively hardened by the addition of a reasonable amount of cement. If a soil meets or closely approximates two or three of these requirements, but not the remaining ones, it will probably fall in Group III. Durability tests similar to those used in this investigation will establish definitely the quantity of cement required for successful treatment.

At the present time more data are needed to define treatment groups closely so that durability tests may be omitted. To accumulate these data as rapidly as possible and to check each soil investigated to be absolutely sure of satisfactory results, it is recommended that all tests outlined in this report be performed on each soil as it is encountered for study.

Work on soil-cement mixtures in the laboratory has progressed rapidly and holds much promise. Definite principles have been established which put soil-cement mixtures on a sound, scientific basis permitting results to be predicted with assurance. Experiences to date show that these laboratory investigations must be made on soils before any field work is attempted.

• • •

Water Power License Granted in Oregon

The Inland Power & Light Co., Portland, Ore., has been granted a 50-year license by the Federal Power Commission to construct a hydroelectric project on Crooked River in Jefferson County, Ore. The development consists of a low rock diversion dam across the Crooked River; an open conduit about 1,700 ft. long extending from the dam to the power house, which houses two water wheels, one of which is connected to a 700-kw. generator and the other to a 400-kw. generator; and a 22,000-volt transmission line extending from the power house to a junction with a transmission line of the Pacific Power & Light Co.

Steel Arch Moved Lengthwise

Flood damage required shifting 230-ft. span at Rumford, Me., 50 ft. to new foundations

A BRIDGE-MOVING JOB of uncommon type, occasioned by the New England floods of 1936, has been completed at Rumford, Maine, where a 230-ft. span three-hinged steel arch over the Androscoggin River has been shifted lengthwise 50 ft. to provide for increased waterway. The work involved building a new pier and one new abutment, raising the 1140-ton span onto rollers by a novel jacking arrangement, moving it along a runway to its new location, and tearing out one old abutment and widening the channel. Between the new pier and the remaining old abutment a 50-ft. girder span has been installed.

The bridge, from whose arch ribs, 28 ft. apart, the concrete roadway is suspended by H-section hangers, was opened to traffic in November, 1935. Taking into account the highest discharge on record, 50,000 sec.-ft. in 1927, the design provided for 60,000 sec.-ft., only to have a flood of 74,000 sec.-ft. attempt to pass the bridge four months later. The result was the washing out of the east approach fill and the undermining of the east support, a remodelled stone masonry abutment used for an earlier bridge at the site. The upstream arch bearing at this end settled about 9 in., and only the presence of a strong, reinforced concrete bridge seat prevented further settlement and possible collapse of the bridge.

More waterway was mandatory and, since the east abutment was so badly damaged, it was decided to widen the channel 50 ft. on this side and build a new abutment. Then, after building a pier 50 ft. out in the river, from the west abutment, the arch could be shifted longitudinally to these new supports, as diagrammed in Fig. 2. In Fig. 1 is shown the completed bridge as it now appears. The concrete retaining wall along the east bank, which extends up and downstream from the new abutment, was built by the WPA as a separate project.

Preparations for moving

It was decided that the bridge could be shifted on rollers operating on a prepared runway. Since there were no structural members in the bridge capable of taking the jacking reactions necessary to raise the span onto the rollers, a novel layout was designed to lift the bridge by its end pins. The details of this layout are shown in Fig. 2. It will be noted that at each shoe two eye-bars were installed, engaging the 9-in. truss pins at the bottom and a 9-in. pin at the top which passed through three short I-beams resting on two 27-in. needle beams in turn supported at each end by cross beams against which the jacks operated. The jacks were supported on blocking on top of the abutments.

One end of the bridge was lifted at a time, the total vertical movement necessary to insert the rollers and two top and bottom bearing plates being about 7 in. The bottom plate was made flush with the top of the runway.

The first half of each runway, adjacent to the original supports, consisted of four 14-in. wide-flange beams for each track, supported by

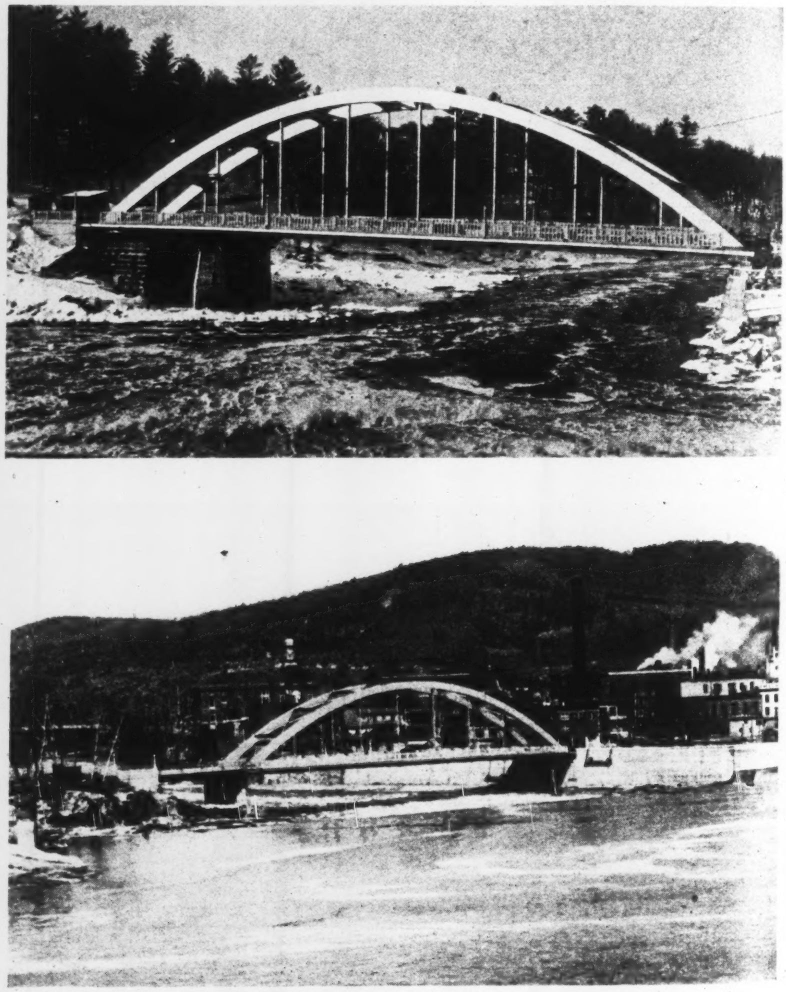


Fig. 1. **Before and after moving the 1140-ton arch at Rumford, Me., to new supports which permit a wider waterway.**

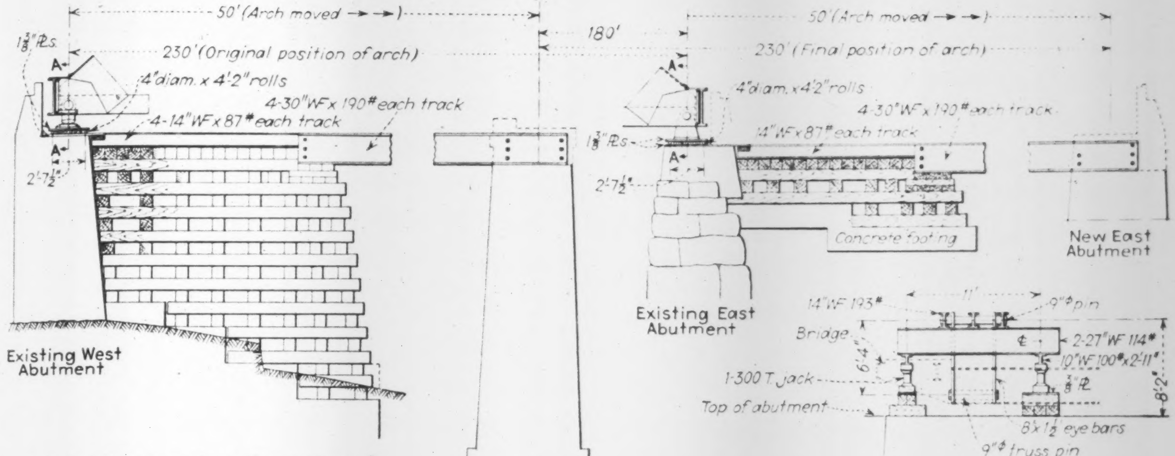


Fig. 2. Layout of bridge-moving runways, including jacking details for lifting span onto rollers.

a crib of hardwood timbers carried on the rock ledge at the west end and on a reinforced concrete footing at the east end. Between these cribs and the new supports the runway for each track consisted of four 30-in. wide-flange beams of about 25 ft. span. Collars composed of two 6x6-in. timbers and 1-in. rods were spaced 8 ft. apart along the beams to keep them from spreading. The runway was on about a 1 per cent downgrade from west to east, which was an aid in moving the bridge.

The power for moving the bridge was supplied by a steam hoisting engine working through a six-part block and falls attached to each end pin and connected to a deadman placed behind the east abutment in direct line with the arches. A similar cable layout was installed at the west end of the bridge to be used as a brake and to permit the span to be moved backward, if necessary.

In moving the bridge, a strain was taken on both the forward and rear cables, and then, as the rear cable was released the bridge moved ahead a few inches. Repetition of this operation moved the bridge the necessary 50 ft. in 10 working hours. Finally, with the bridge in final position, the 30-in. track beams were burned off outside the rolls, and the beam stubs and rolls were concreted into the tops of the new pier and abutment.

The work was designed and carried out under the supervision of the Maine state highway commission, Max L. Wilder, state bridge engineer, and Andrew Adams, resident engineer. Wyman & Simpson, Waterville, Maine, was the contractor.

Resurfacing the Cape Cod Canal Bridges

MOISTURE PENETRATION into deck slabs of lightweight-aggregate concrete surfaced with asphaltic concrete on the Cape Cod Canal bridges at Bourne and Sagamore, Mass., has resulted in the letting of a contract for their repair and resurfacing less than three years after the bridges were completed. Independent investigations made by the Boston Engineer District of the Corps of Engineers, which has jurisdiction over the bridges, and by Fay, Spofford & Thorndike, consulting engineers, Boston, who designed the bridge, established the deterioration. The repair methods now being employed are based on a number of tests conducted by the army engineers to determine an appropriate method of insuring complete waterproofing of the roadway deck.

The bridges, of high-level, continuous truss type, with 616-ft. main spans constructed during 1934-35, were built with 40-ft. roadways consisting of a bituminous concrete surface placed on a waterproofing coat of cutback asphalt over a 7-in. reinforced concrete slab made with aggregate of burned shale or clay known commercially as Haydite. The bituminous concrete surface was placed in two courses, a $1\frac{1}{2}$-in. base course and a $\frac{1}{2}$-in. surfacing. Steel reinforcement consists of continuous prefabricated trusses made up of reinforcing bars connected by welded web members. The roadway was divided into four lanes by traffic markers of hard, white-marble concrete 2 in. thick.

According to information from Capt. James H. Stratton, chief, engineering division, U. S. Engineer Office, Boston, a break occurred in the roadway deck of the center span of the Bourne Bridge on May 10, 1937, just outside of one of the side traffic markers. The break was 18 in. long and the roadway surface for about a foot each side was depressed, with cracks in the concrete slab showing above the reinforcing trusses. Although not serious and easily repaired, the break, occurring less than two years after the bridge was put in service, was considered to merit investigation.

The remedial action recommended consists of the removal of the side traffic markers and the waterproofing of the deck slabs with a $\frac{1}{2}$-in. layer of sheet asphalt on which is to be placed a $\frac{1}{2}$-in. wearing surface of asphalt-coated peastone. This surface treatment is commercially known as Granovia wearing surface and is patented by the Warren Brothers Co., Cambridge, Mass., which has the contract for applying 16,770 sq. yd. of it on the two bridges at a unit price of 73 cents. The additional weight of the deck due to the new surface treatment is estimated at about 11 lb. per sq.ft., which the consulting engineers agree will not seriously reduce the factor of safety.

Lansing Pioneers in Garbage Digestion

New sewage treatment plant for Michigan's capital city will include facilities for grinding garbage and digesting it with sludge

HOLDING more than usual interest for the sanitary engineer is the new sewage disposal plant now under construction at Lansing, Mich., where garbage will be digested along with sewage sludge. This is probably the first plant to incorporate permanent facilities for handling garbage disposal by this method, the practicability of which has been studied extensively in laboratories and under some plant scale operating conditions. Other features of the plant in addition to the provision for garbage digestion also invite attention. Among these are the use of many mechanical treatment devices including a centrifuge for reducing the moisture of activated sludge prior to its digestion, pre-aeration for the flotation of grease, sludge incineration in a multiple-hearth furnace with separate drying zones, and power production from a digester gas.

In this 9 m.g.d. (dry-weather flow) activated sludge type plant, the designers have provided capacity for the disposal of garbage and sewage from a contributory population of 100,000. Strength of the sewage to be treated is indicated by analysis which shows a 5-day biochemical oxygen demand of from 200 to 300 p.p.m. and a suspended solids content varying from 250 to 300 p.p.m.; the presence of large amounts of waste oil in the sewage made it desirable to provide pre-aeration treatment. Studies of garbage collection reveal that the daily per capita production is about 0.5 lb., the moisture content averaging 75 per cent. Total daily collections (on a dry basis) vary from 14 to 40 tons, depending on the season of the year.

Plant layout

The plant layout is so arranged that all primary treatment processes are housed in a single building. The purpose of this is to minimize any conditions which might be offensive to sight or smell. To this end, special provisions have been made to control odors, most of which are apt to become noticeable in the preliminary stages of treatment. Air from the building can be exhausted by means of fans and discharged either to the chimney or to the forced draft of the incinerator. In addition, small ventilators have been installed in the walls of the building to facilitate changing of air. To assure good lighting, glass blocks have been used in much of the wall space, and skylights have been built in the roof.

Sewage coming from a pumping station three-quarters of a mile away, passes through a venturi meter to the grit chamber provided with a grit cleaning and removing mechanism. From here it passes to comminutors and then into the pre-aeration tank.

After ten minutes detention the sewage flows to the primary tanks, four in number, each 16 ft. wide and 70 ft. long. These tanks, providing a nominal detention period of one hour, are equipped with longitudinal sludge scrapers, the blades of which serve as skimmers when they return along the water surface. Grease and scum previously floated by pre-aeration are thus removed and can be pumped either to the digestion tank or to the sludge incinerator.

Secondary treatment devices

Secondary treatment of the clarified sewage, consisting of aeration with activated sludge and sedimentation, is provided in structures located in the open. There are four aeration units, each consisting of two rectangular tanks, the tanks are 15 ft. wide, 210 ft. long and 16.5 ft. deep. In the 420 ft. of travel provided for the sewage, air is supplied

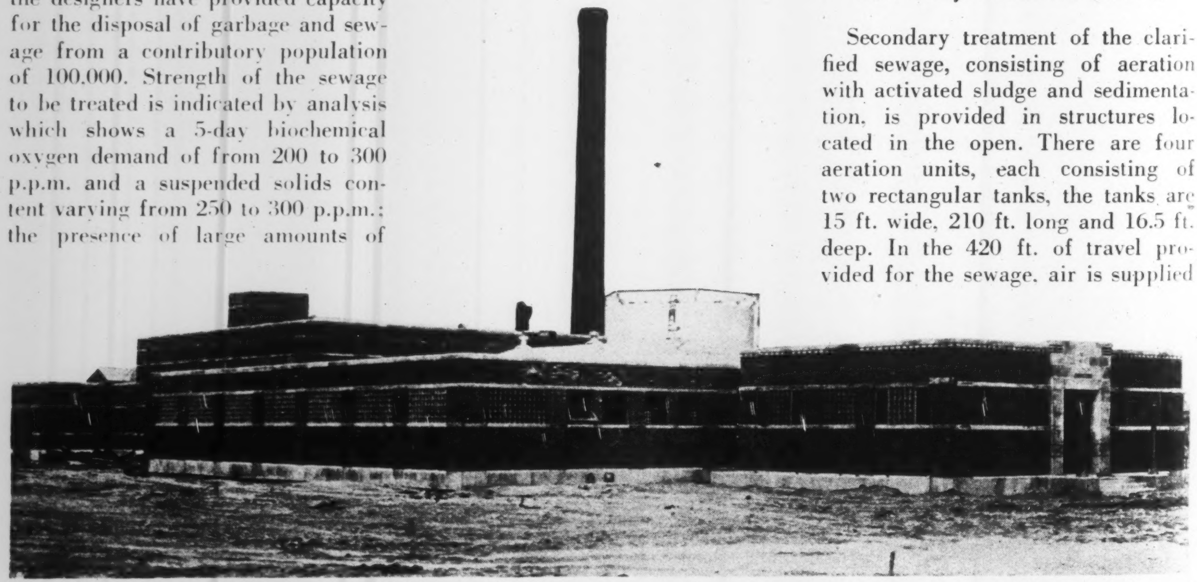


Fig. 1. Glass block panels and liberal window areas characterize the laboratory, primary tank and sludge handling buildings of the Lansing plant.

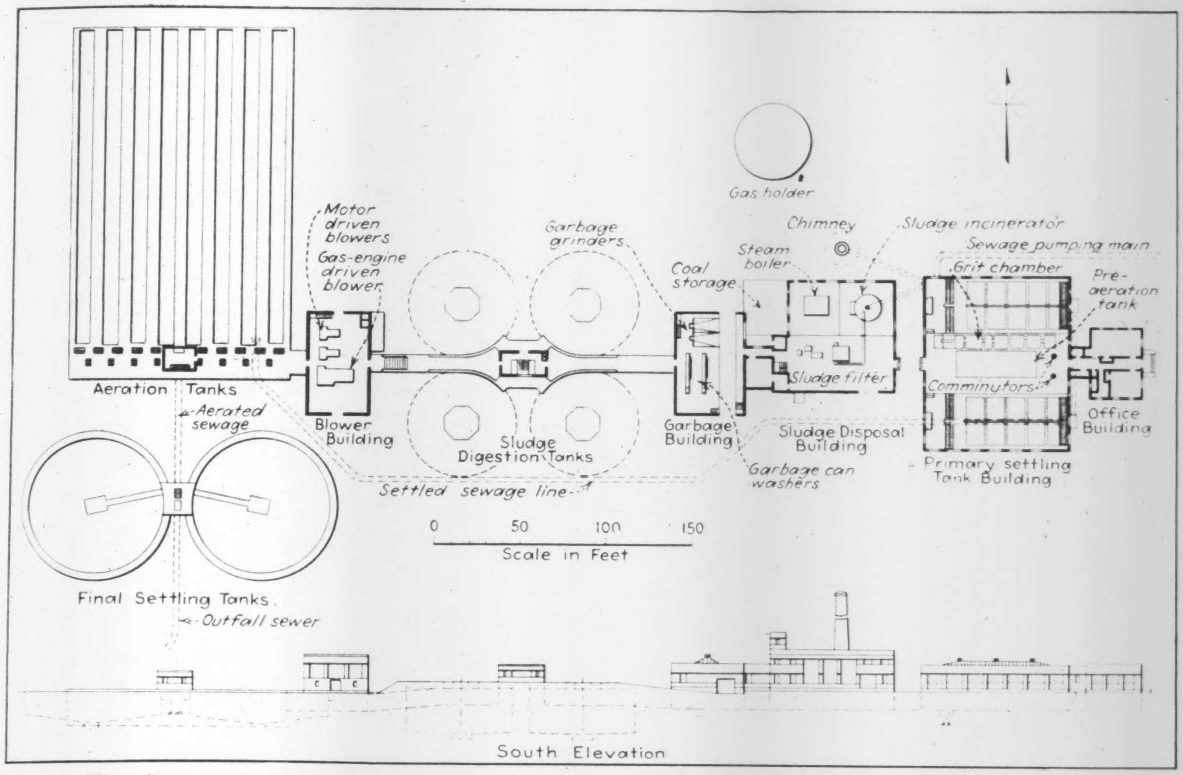

Motor driven blowers
Gas-engine driven blower
Garbage grinders
Gas holder
Chimney
Sludge incinerator
Sewage pumping main
Steam boiler
Coal storage
Grit chamber
Pre-aeration tank
Aeration Tanks
Aerated sewage
Blower Building
Sludge Digestion Tanks
Garbage Building
Sludge filter
Sludge Disposal Building
Comminutors
Office Building
Primary settling Tank Building
Garbage can washers
Settled sewage line
0
50
100
150
Scale in Feet
Final Settling Tanks
Outfall sewer
South Elevation

Fig. 2. General layout of the treatment and handling facilities for the disposal of both sewage and garbage.

by two rows of diffuser plates in the bottom of the tanks, the design of which imparts spiral type flow.

After six hours of aeration the sewage is settled in two circular settling tanks designed for radial flow distribution. These 80-ft. diameter tanks provide for a settling rate of 1,100 gal. per sq.ft. per day. The effluent passes over a white, glazed tile weir into a common chamber serving both tanks, and this discharges into the outfall sewer.

In order to provide sufficient capacity for the storage of both sludge and garbage, four digestion tanks each holding 75,000 cu.ft. are provided. These reinforced concrete tanks, with an inside diameter of 60 ft. and an average depth of 26.5 ft., have a concrete roof. Heating coils and sludge scraping and scum breaking mechanisms are installed.

A welded steel plate gas-holder, capacity 25,000 cu.ft. is used for the storage of digester gases. The tank is 45 ft. in diameter and fitted with a movable section of such weight that the gas, regardless of the quantity in storage, will be at a minimum pressure equivalent to 8 in. of water.

Waste activated sludge from the final sedimentation tanks will be partially dewatered prior to digestion in order to minimize heat losses in the digesters and reduce the quantity of supernatant liquor to be handled. For this purpose a 1,500 gal. per hr. centrifuge will be employed to reduce the sludge moisture content from 99 to 91 per cent. The removed liquor will be returned to the plant influent for further treatment.

How garbage is handled

Garbage collection procedure in Lansing lends itself particularly well to the disposal method adopted. The city supplies standard size house receptacles for garbage only and these are collected at regular intervals and replaced with a clean, washed can. The full cans are carried to a central transfer station when they are emptied and cleaned with hot water, and sterilized with steam. This system has been used successfully since 1920.

There are no difficulties in transferring these operations to the sewage treatment plant where a separate garbage handling building has been built adjacent to the sludge digestion tanks. As shown in Fig. 2, this building provides platform facilities for unloading the cans, and washing them as before. However, in place of dumping the garbage in another truck for removal to a hog farm, as was done heretofore, the material is merely dropped into hoppers beneath the platform which feed into two hammermill grinders. The ground garbage is then transported to the digestion tanks by means of pneumatic ejectors.

The grinders, each with a capacity of 6 tons per hr., are equipped with a refuse trap which removes tin cans,

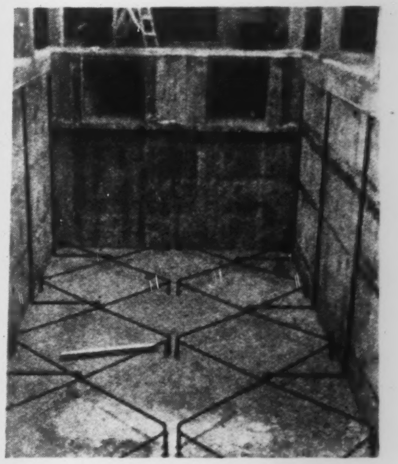


Fig. 3. Pre-aeration tank for the flotation of grease.

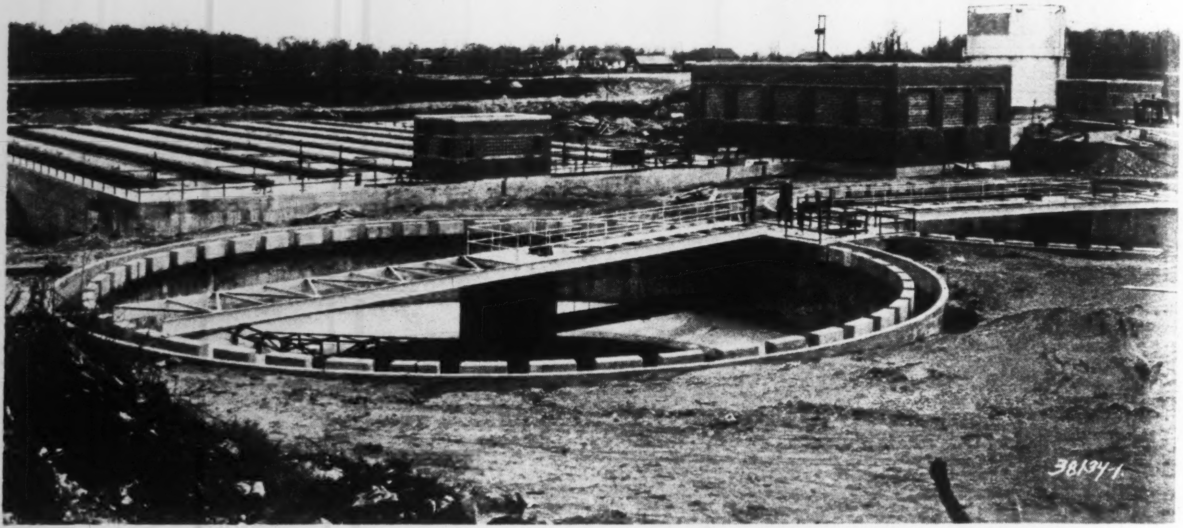
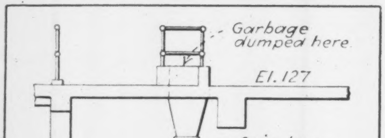


Fig. 4. Final settling tanks, aeration units and blower building. The tops of the digestion tanks, which are entirely underground, can be seen at the right.

tramp iron and similar material. Spray pipes in the uppar part of the grinder housing supply water for washing the garbage through the rotor and screen below.

The ejector tanks have a capacity of 200 gal., and are so designed that a charge of ground material (minimum moisture content 70 per cent) can be ejected for a distance of 150 ft. through an 8-in. pipe. This pipe rises upward 16 ft. so that the material will discharge into an open well above the digester and from there drop by gravity into the tank. The valves for operating the ejector are manually controlled from a panelboard on which are also located signal devices indicating when the ejectors are ready to be discharged.



Sludge disposal facilities

All operations concerned with sludge disposal and by-product utilization are housed in a separate building designed to facilitate this service. It contains a vacuum filter of 200 sq. ft. surface area, chemical conditioning equipment for dewatering sludge prior to incineration, a 60-ton incinerator, a 240-hp. gas engine connected with the aeration system blowers, and a steam boiler for the can-washing plant.

The incinerator is of the multiple-hearth type with separate drying zones. Sludge cake with a moisture content of about 70 per cent discharges into the top of the furnace, which consists of six circular hearths, one above the other. The first two hearths are used for drying at temperatures low enough to prevent scorching or charring of the sludge surfaces, which would otherwise inhibit the drying process. Burning, with the aid of auxiliary oil fuel is carried on at high temperatures in the tier of hearths below. The gases from the drying hearths are passed through the high temperature zone for the destruction of odors.

The incinerator can be operated either to convert sludge to an ash or to provide a dry material of 7 to 8 per cent moisture content which can then be sold for fertilizer.

The treatment plant, including a 25 m.g.d. pumping station and force main, is costing $930.000 of which $405.000 was made available by a PWA grant. Work was started in January 1937 and will be completed in June of this year.

Direction

Design and supervision of the work is under the direction of Shoecraft, Drury & McNamee, consulting engineers, Ann Arbor, Mich. Architectural services in connection with the plant structure were performed by L. & K. C. Black of Lansing. Representing the city's interest in the job is S. C. Jacka, city engineer. George F. Wyllie is resident engineer.

Columbus Plans Extension For Municipal Plant

Although Federal financial aid on the engineering cost will not be available immediately, the City of Columbus, Ohio(has decided to begin preparing plans for the $1.030-000 PWA extension of generating facilities at the municipal light plant. Following a conference between service director Llewelyn and L. A. Boulay, state PWA administrator. Lewis states that the city did not expect immediate release of the $65-000 of federal aid.

Plywood For Gusset Plates

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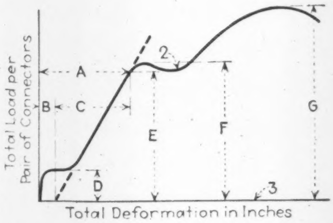
Laboratory studies develop data on design of joints made with plywood and ring connectors

INVESTIGATIONS conducted at Pennsylvania State College in 1933 and 1934 (*ENR*, January 10, 1935, p. 40) demonstrated that the use of heavy plywood for gusset plates in timber trusses is feasible. The investigation, however, being in the nature of a pilot test, did not establish design data but did indicate a need for further information especially with respect to the action of timber connectors in lumber and plywood. Then, too, the preliminary investigations demonstrated the need for additional data concerning the load-bearing capacity of multiple pairs of timber connectors as well as the deformation to be expected in a joint. With these thoughts in mind the writers proceeded with the investigation and offer the following as a progress report.

Discussions concerning the action of timber connectors in structural joints have emphasized the need for a standard nomenclature and a definition of terms. To meet this need the investigators have prepared a chart (Fig. 1) as a graphic explanation of what may be expected of a timber connector joint when loaded. In this article descriptive terms will be used within the limitations of Fig. 1. It will be noted from the chart that the deformation for any assembly, within the range of working loads, can be computed by dividing the "load per pair of rings" by the "slope" and adding the "initial slip at zero load."



A = Actual deformation at proportional limit
B = Initial slip at zero load
C = Net deformation at proportional limit
D = Friction load
E = Load at proportional limit
F = Load at first failure (core shear)
G = Load at ultimate (or maximum load)
E/C = Slope (comparable to modulus of elasticity)
1 = First slip (or slip after friction load has been exceeded)
2 = Second slip (or slip after first failure)
3 = Base line (zero load)

Fig. 1. **Terms used in describing tests for ring connector joints.**

A beveled connector

Preliminary tests indicated the possibility of improvement in the design of the standard timber connectors (Type A in Fig. 2), and a beveled connector with less depth (Type B) was therefore developed. This connector may be installed in a joint with less loss of cross-section in the members because of its reduced depth. Tests also demonstrated that, since it was designed to fit in a tight groove, there was less initial slip at zero load and that this beveled connector provided stiffer joints, higher load at proportional limit for lumber, and higher loads at first failure (core shear) for both lumber and plywood assemblies. Assembly tests with the standard connector in both lumber and plywood showed somewhat higher ultimate load capacities as indicated in the accompanying table.

No extensive tests were planned to study the relative overturning moments of the two types of connectors. Nevertheless, the test results indicated quite definitely that a lower overturning moment was developed by the beveled connector—undoubtedly due to the beveled contact surface.

The desirability of beveling the ring to reduce overturning moment was demonstrated by the relatively large test loads carried by assemblies in which the customary bolts were omitted. These test loads were considerably larger than customary design working loads but considerably smaller than the ultimate loads obtained with assemblies containing bolts.

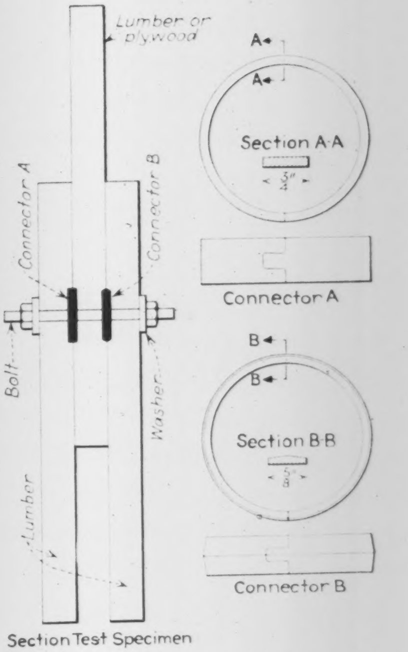


Fig. 2. **Standard test specimen and details of square and beveled connector rings.**

Load capacity of joints

Basic tests were made on many similar assemblies (Fig. 2) loaded in compression. In every assembly the two exterior pieces were Douglas fir lumber 1⅝x3⅝-in. in cross-section. The center pieces were either Douglas fir lumber or Douglas fir plywood. In all cases the lumber used was matched for grain and density in order that the results of one test might be compared with the results of another.

The plywood used was commercial grade 1⅝ in. thick, made from standard commercial veneers and glue. Because of the fact that loads may be brought into gusset plates at any angle, separate tests were made of assemblies in which the grain of the face plies of the plywood center pieces varied from zero to 90 deg. with reference to the direction of the load. It will be noted from the table that the loads at the proportional limit, first failure, maximum (ultimate), and the deformations are affected by the angle of applied load to direction of grain. The nature of these test failures and results of tests now in progress indicate that the width of center piece in these assem-

TEST LOADS AND DEFORMATIONS FOR ASSEMBLIES CONTAINING ONE PAIR OF 2½ IN. SPLIT CONNECTOR RINGS WITH ONE ½ IN. BOLT AT AN INITIAL TENSION OF 1800 LB.

Center Piece of Assembly	Type of Connector Rings	Number of Assembly Tests	Dimensions of Center Piece in In.	Angle of Load to Direction of Grain (of face ply for ply-wood) in Deg.	Load* Per Pair of Rings (Lb.) At Proportional Limit	Load* Per Pair of Rings (Lb.) At First Failure (core shear)	Load* Per Pair of Rings (Lb.) At Maximum	Deformation** Initial Slip at Zero Load in In.	Deformation** Slope*** (Lb. per pair of rings per in.)
Fir Lumber	Standard	8	1⅝ x 3⅝	0	9,290	10,520	20,660	.014	208,000
		3	3 x 3⅝	0	10,290	10,790	23,560	.016	218,000
	Beveled	6	1⅝ x 3⅝	0	9,820	12,100	19,320	.006	393,000
		2	3 x 3⅝	0	10,440	11,860	21,240	.004	563,000
Fir Plywood	Standard	1	1⅝ x 3⅝	0	7,500	9,000	14,375	.027	163,000
		1	1⅝ x 3⅝	22½	8,500	11,000	13,470	.014	146,000
		1	1⅝ x 3⅝	45	6,000	7,750	10,700	.014	125,000
		1	1⅝ x 3⅝	67½	6,000	7,850	12,330	.020	115,000
		1	1⅝ x 3⅝	90	5,500	6,750	13,600	.022	131,000
	Beveled	3	1⅝ x 3⅝	0	6,330	11,370	13,310	—.007	288,000
		3	1⅝ x 3⅝	22½	6,000	11,430	12,770	—.006	285,000
		3	1⅝ x 3⅝	45	6,000	9,470	10,000	—.004	243,000
		3	1⅝ x 3⅝	67½	7,000	10,620	11,950	—.006	258,000
		2	1⅝ x 3⅝	90	7,330	11,130	13,670	—.007	223,000

* Test loads adjusted to 12 per cent moisture content.

** Test deformations are values at about 17 per cent moisture content of lumber and at 12 per cent moisture content of plywood.

*** Slope is comparable to modulus of elasticity (See Fig. 1).

blies was too small to develop the full load carrying capacity of the plywood.

In addition to the basic tests made for the purpose of determining the load-bearing values of timber connectors in plywood, certain supplementary tests were made. For example, it was determined that bolt tension is an important factor in the load-bearing capacity of joints—doubtless because of its relation to friction. An initial bolt tension of 1800 lb. on the ½-in. bolt was adopted as standard for test purposes. It appeared that the load carried by friction was approximately equal to the total tension in the bolt.

Then, too, the conventional compression and shear tests on small minor specimens were found to be indicative, so far as quality of lumber is concerned, of what load may be expected in a joint assembly. Furthermore, the results of the compression and shear tests on minor specimens were necessary for moisture content corrections. These adjustments, which brought all results to a uniform 12 per cent moisture content basis, were made in accordance with the standard exponential formula given in Technical Bulletin No. 282 of the U. S. Forest Products Laboratory. No moisture content adjustments were made for plywood because its moisture content was very close to the basic 12 per cent.

Design recommendations

Tests on multiple assemblies of connectors in a practical joint are as yet not far enough advanced to support positive recommendations for design. However, a study of all the available results to date leads the investigators to believe that certain conclusions of value to engineers may now be made.

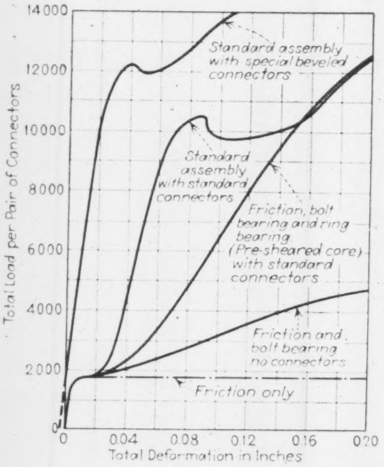


Fig. 3. Typical load-deformation curves showing contribution of friction, bolt bearing and ring bearing to capacity of the joint.

For example, if all bolt holes and grooves are in perfect alignment through the whole assembly and if the net section is not overstressed, it is reasonable to assume that, within reasonable limits, multiple pairs of rings will carry approximately as much axial load in lumber assemblies as the same number of rings loaded as single pairs. Since, in commercial fabrication this condition of alignment may be difficult to attain, it is probable that for ordinary construction some reduction of load should be assumed for assemblies of multiple pairs of connector rings.

Again, assuming accurate alignment, it also seems reasonable to assume that the initial slip at zero load for an assembly of multiple pairs of rings is about the same as that for one pair of rings. Also, that the elastic deformation for the whole assembly of multiple pairs of rings is about the same as for an assembly of a single pair of rings loaded with its proportionate share of the assembly load. That is, the total deformation of an assembly of multiple pairs of rings is the same as that for an assembly of a single pair of rings.

In Figure 3 is shown graphically a summary of the load-deformation characteristics of single pair timber connector joints in lumber within working limits. This illustration also shows the elements of friction, bolt bearing and ring bearing, all of which, acting together, provide the load-bearing capacity of a timber connector joint. Of particular significance is the comparison of the total deformation of the two types of rings under equivalent loads. It will also be noted that the amount of initial slip in an assembly of a single pair of rings is largely dependent upon the clearance between the ring and its groove.

So far as working loads for design purposes are concerned, it is customary in commercial practice to assume a factor of safety of 1.6 on the proportional limit and 3.5 on the maximum (ultimate) load—whichever gives the smaller working load. In Europe, where connectors have been in use much longer than in the United States, it is customary to use a somewhat smaller factor of safety. Tests revealed that, with either the standard or beveled ring, the shear and load-bearing capacity of the lumber or plywood ordinarily governed, rather than the strength of the ring. Attention should be called to the fact that lumber is stronger parallel than perpendicular to the grain, and that the test results above are given for loads applied parallel to the grain. It will also be noted from the table that an assembly with 3-in. center piece of lumber supports a larger load than one with a 1⅝-in. center piece—presumably because the center piece, in which two rings are embedded back to back, has a larger net section.

It is advisable to inspect joints and tighten bolts after a structure has been completely assembled and placed in service. The standard edge margins recommended for the installation of connectors in lumber should be increased for plywood. A minimum edge margin of 3-in. and a minimum spacing and end margin of 5-in. from the center of 2½-in. connectors is suggested for plywood until more information is available.

As a result of the numerous tests made to ascertain the value of plywood as a gusset plate material, the investigators are of the opinion that plywood to be used for this purpose should be specially selected. Commercial material is likely to have structural defects or a lack of homogeneity which may materially affect its effectiveness for gusset plates.

Flood Control in Orange County Ready for Early Start

Southern California project just starting, including eight earthfill dams, to cost $15,248,000

CONSTRUCTION is to begin soon on a flood control and water conservation program in Orange Co., Calif., where plans for the project have been studied carefully for nearly a decade. The program includes a storage or retarding basin on each of eight streams with an earthfill dam on each. Including incidental work and land damage, the estimated cost of the improvement totals $15,248,000, of which $12,748,000 is to be supplied by the federal government (project already approved; appropriations to be made as the work progresses) and the remaining $2,500,000 is provided for by a county bond issue voted in July, 1937. The Orange County Flood Control District will supervise expenditure of that part of the total cost required for acquisition of lands, moving of public utilities and relocation of railroads and highways. The major portion of the construction, including all items not assigned to the district, will be carried out by the fifth field area engineer, under the direction of the district engineer of the U. S. Engineer Department.

The need for a flood control and conservation program in Orange County was emphasized by the floods of 1916, which caused serious and widespread damage. Since then the population has more than doubled and the assessed valuation has trebled. Recent investigation of rainfall and runoff records extending back to 1771 indicates that floodflows from the eight streams in the county may total 215,000 sec.-ft. and within the period of historic record the average period between floods is about 5 years. Along the northeast boundary of Orange County the terrain is mostly mountainous, with peaks ranging up to El. 5600. However, the major portion of the area is a coastal basin with much rich land and gentle slopes well adapted to cultivation. The district has an ocean frontage of about 38 mi. and extends inland some 20 mi. Within this area of 510,000 acres are thirteen incorporated cities (35,000 acres), some 150,000 acres of land already under irrigation and some 75,000 acres not irrigated but adaptable to irrigation. Property valuation last year was placed at $187,000,000 and the population was estimated at 130,000.

The March 1938 flood, whose effect in Orange County was shown in a striking way in *ENR* June 9, 1938, p. 806, puts the greatest possible emphasis on the need for flood storage particularly on the Santa Ana River.

As the irrigated area of the county has increased in recent years, additional draft on underground water supply has resulted in the usual drawdown of subterranean storage. Between 1924 and 1936 the depth of the water table, as measured at 15 points within the county, had increased by amounts varying from 10 to 110 ft.; the average drop for the 15 points was 44 ft. Since the cost of bringing in water from outside sources is estimated at $15 per acre-ft., a very important feature of the program is the conservation of the floodwaters that now waste into the sea. The plan is to release these through spreading basins into the underground reservoirs.

The movement toward working out a program of flood control and conservation took definite shape in the first flood-control bond issue, which was submitted to the voters in June 1929. This first plan of protection and conservation was developed by Paul Bailey, previously state engineer, retained as first flood-control engineer by the district, which had been organized in 1927 with boundaries identical with those of Orange County. This bond issue, which was for $16,500,000, was defeated by a slight majority.

Three other bond elections followed. A proposed issue of $6,600,000 in October 1935 failed, as did an issue of about the same amount in December 1935. In the latter part of 1936, however, it became apparent that the district could obtain the desired flood-control works, much as called for under the original program, by voting a relatively small bond issue to supplement an allotment of federal funds. Federal aid had been authorized under the June 22, 1936, Act of Congress, and allotment to this project was contingent only upon the county's providing its share. Under these conditions the fourth and last bond issue, which was for $2,500,000 and was submitted to voters in July, 1937, carried by a majority of 10 to 1 (*ENR* Aug. 12, 1937, p. 283). Federal-aid will add $12,748,000.

Since the approval of the district bond issue, which removed the last obstacle to a start on construction, previous plans and estimates have been checked, location surveys and final design have been made and contracts have been let for drilling test holes at all eight dam sites. By the end of 1937 drilling had been completed at some of the sites and detailed cost estimates had been prepared for submission to the next Congress. In general, it is the expectation that it should be possible to work out a

TABLE I — MAIN FEATURES OF EIGHT EARTHFILL DAMS FOR FLOOD CONTROL IN ORANGE COUNTY

Project Number	Stream	Drainage Area (sq. mi.)	Dam Height (ft.)	Dam Length (ft.)	Preliminary Spillway Capacity (sec.-ft.)	Preliminary Reservoir Capacity* (acre-ft.)	Peak Reduction (sec.-ft.)
1	Santa Ana River	2,280	100	2,350	300,000	180,000 325,000	115,000
2	Brea Basin	25	85	1,250	50,000	3,300 6,100	3,350
3	Fullerton Creek	5	45	500	20,000	800 1,660	1,340
4	Carbon Canyon	12.7	120	770	34,000	2,500 3,100	4,200
5	San Juan Creek	107.0	116	2,500	120,000	25,500 38,500	25,000
6	Arroyo Trabuco	32	100	1,250	57,000	3,900 6,100	4,900
7	Santiago Creek	63	165	1,450	86,000	47,000 60,000	18,050
8	Aliso Creek	3.5	80	720	16,000	500 765	....

* In each case the lesser figure refers to spillway crest level and the greater figure refers to maximum water surface elevation.

TABLE II — ESTIMATED TOTAL COSTS OF THE PROJECTS

Project	To be Paid by: Federal Government	To be Paid by: Flood Control District
Santa Ana River	$4,900,000	$1,763,500
Brea Creek	701,000	90,110
Carbon Canyon	1,398,000	152,190
San Juan Creek	2,171,000	52,000
Arroyo Trabuco	1,379,000	9,600
Santiago Creek	1,527,000	68,865
Fullerton Creek, Loftus Diversion, etc.	310,000	293,280
Aliso Creek	362,000	18,900
Incidental Expenses, etc.	....	51,555
	$12,748,000	$2,500,000

construction plan that will complete the entire program in about three years.

On this basis the expenditures in the first year would be about $1.-500,000; in the second year. $5,600,000, and in the third year $5,648,000. These figures refer to the expenditures on new construction under supervision of the U. S. Engineer Department and are in addition to the amount to be spent by the district in land damage and relocation work. The estimates are based on the expectation that most of the work will be done by contract and that the largest single undertaking, the Prado Dam, listed as project 1, will begin in 1938. An argument for early construction is that it may be possible to store the 1938-39 flood runoff of the Santa Ana River in this reservoir if a sufficiently early start is made on the project.

Table I gives the essential data relative to the eight dams. The column headed "Peak Reduction" refers to the expected effect of the reservoir on the maximum flood flow at the dam site. All dams have slopes of 3 to 1 on both sides except the Prado Dam (project No. 1), whose downstream slope is 6 to 1. Additional protection on this slope also is provided in the form of two berms to insure catchment of rainfall and reduction of erosion.

The estimated total cost, Table II, does not refer to the dams alone but includes all elements of each project, such as conduits, channel protection works, spreading grounds, canals, etc.

The original consulting board appointed in 1927 consisted of F. C. Herrmann, Chas. H. Paul, and the late A. J. Wiley. When the work was revived in February, 1930, a new board was appointed consisting of B. A. Etcheverry, Thos. H. Means, and the late Geo. A. Elliott. At the present time the consultants, reporting directly to the U. S. Engineer Department, are Louis C. Hill, Wm. P. Creager, Walter J. Douglas, and Thaddeus Merriman. In the present organization M. N. Thompson is flood-control engineer of the Orange County Flood Control District, and R. P. Spencer is area engineer at Santa Ana, the county seat of Orange County, for the U. S. Engineer Department; Major Theodore Wyman, Jr., is district engineer of the U. S. Engineer Department at Los Angeles in charge of the entire area.

One-Way Traffic Rule Enforced by Automatic Device

A DEVICE built into an automobile roadway near the administration building of the Golden Gate Bridge permits automobiles to pass in one direction but automatically maintains a barrier against traffic in the opposite direction. The device was needed to prevent by-passing the toll gates by automobiles going to and from the administration building. It is on a paved roadway 10 ft. wide between curbs and has been operating successfully since it was put in service shortly after the bridge was opened to traffic.

Essentially the device is a hinged platform constituting a 3-ft. length of the road surface. The platform consists of three 3x12-in. planks fastened to steel I-beam supports which frame to a hinge at roadway level along the edge toward traffic that approaches in the permissible direction. Counterweights keep the platform raised, that is, inclined upward from the hinge at roadway level, thus presenting a raised barrier to traffic approaching in the wrong direction. In other words, the free edge of the frame, rotating about the hinge, is kept raised about 10 in. This raised edge is painted with the usual traffic barrier markings as a warning to approaching traffic; if the warning is disregarded the barrier is substantial enough to stop a car coming in the wrong direction.

Traffic approaching in the permissible direction starts to climb the incline, swings it downward to roadway level under the weight of the wheels (jar is prevented by a pair of heavy auto-truck shock absorbers) and the car passes over smoothly without delay.

Convenient means of access to the operating chamber beneath the platform is desirable because of the necessity for occasionally removing newspapers and other debris that accumulate in this open space below roadway level.

The automatic traffic barrier was developed by Russell G. Cone, Engineer, Golden Gate Bridge.

Drains Remove CO_2 From Tunnel

Corrosion in steel siphons of Los Angeles aqueduct greatly decreased by drawing off gas through a drain before it enters the water

Entire success has attended an unusual method employed in solving a still more unusual problem that arose from CO_2 gas entering the Los Angeles Aqueduct in one of the Owens Valley tunnels. The corrosive quality of the water caused by this gas greatly increased the cost of maintenance in the steel siphons and in 1936 plans were laid to remove the cause by draining away the gas. The controlling conditions and the methods proposed for carrying on the work were set forth in *Engineering News-Record* Dec. 3, 1936, p. 790. In the following are reported results of the drainage project.

Analyses of gas entering the aqueduct in the Soda Hill district showed it to be 98 per cent CO_2 and the quantities that came in were found to average about 8.3 tons per day. A survey made Aug. 12, 1936, showed evidence of carbon dioxide in the water as far south as Antelope Valley, 100 mi. down the aqueduct from the Soda Hill source.

Expressed in other terms, the carbon dioxide gas was of a quantity sufficient to impart to the water an acid quality equivalent to the addition of 18.5 tons of sulphuric acid daily. The quantity of water normally flowing was such that this acid accretion was very greatly diluted, yet the excess of carbonic acid which resulted not only accelerated algae growths at reservoirs below, which impaired the potable quality of the water, but caused a decidedly corrosive effect on steel pipes.

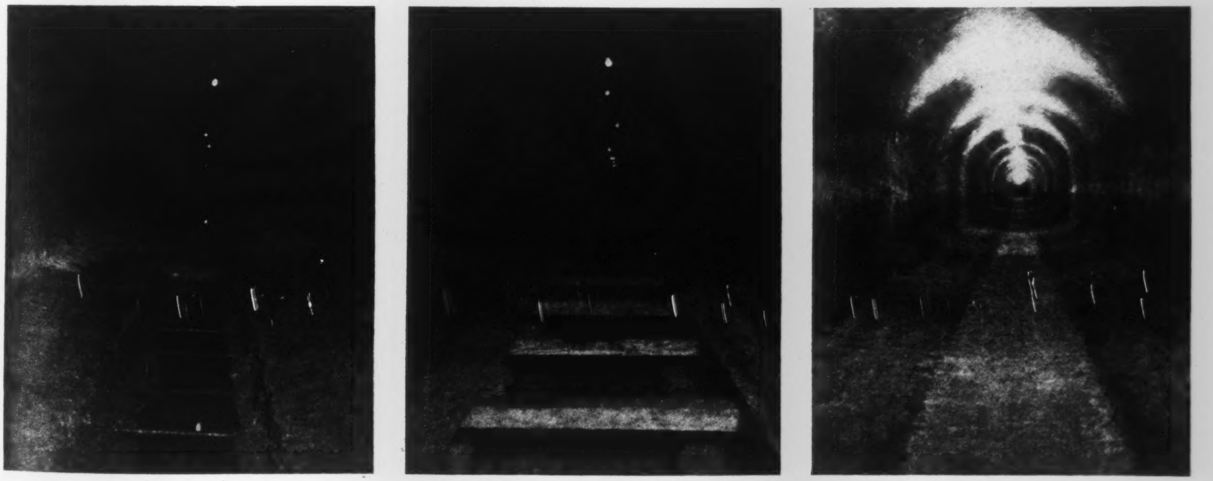
In Haiwee Reservoir the aqueduct water picks up enough calcium carbonate to lay a protective coating in metal pipes if no acid interference were present. In the presence of CO_2, however, the carbonates are converted into bicarbonates, thus destroying the desirable tendency of the water to do its own maintenance work, in a sense, by depositing on the inside of the long steel siphons a lining that tends to resist corrosion and tuberculation.

To remedy the acid condition, longitudinal gas drains in the invert of the tunnel lining were put in as described in the previous article. Successive stages in the work of opening up the tunnel invert, excavating a ditch in the underlying rock and replacing the concrete are shown in the accompanying pictures. In excavating the ditch a shoulder was left on either side just below the bottom of the invert slab and lengths of galvanized sheet iron later were laid on these shoulders as the bottom form for concrete used in restoring the invert.

The gas entering the tunnel was a factor in the reconstruction operations and special provisions for ventilation were made. The CO_2 entered the tunnel at the rate of 130,000 cu. ft. per day. Hence, while the work was under way three blowers, each of 3,000 cu. ft. per min. capacity, were kept in operation. Analyses showed that carbon dioxide content was kept well below 1 per cent as a maximum wherever men were working. This content is far below the percentage dangerous to human life.

After work in the tunnel had been completed and water was again flowing in the aqueduct, chemical analyses were repeated with the results given in Table I. This shows that the gas drainage trenches are entirely successful and that carbon dioxide no longer gets into the aqueduct.

Since the CO_2 gas has been eliminated, the carbonate picked up in Haiwee Reservoir can be traced all the way through the aqueduct to the distribution system, thus carrying their advantages that far. Savings ascribed directly to the elimination



Interior of Soda Hill tunnel showing the trench excavated in the invert, the galvanized iron bottom form and added reinforcing bars, and at the right the restored invert. Planks in the center picture are for the concrete buggies.

COMPARISON OF WATER CONTENT BEFORE AND AFTER GAS DRAINAGE

Station	Distance Below Soda Hills (miles)	CO_2 Before (p.p.m.)	CO_2 After (p.p.m.)	Carbonates (Protective) Before (p.p.m.)	Carbonates (Protective) After (p.p.m.)	pH Before	pH After
Above Soda Hills	....	0	0	16	25	8.27	8.65
Nine Mile Siphon	5	3.9	0	0	25	7.65	8.70
Freeman Station	26	2.8	0	0	25	7.84	8.71
Jawbone Siphon	46	2.5	0	0	25	7.92	8.71
Antelope Siphon (S. end)	99	2.3	0	0	20	8.05	8.61
San Fernando Res.	143	Trace	0	0	10	8.10	8.4
Franklin Res.	155	0 to tr.	0	0–5	15	8.20	8.4
Distribution System	161	0 to 2.1	0	0–1	12	8.00	8.2

of the CO_2 gas, including cleaning and painting the inside of the long siphons, repair of valves and maintenance in the distribution system generally are estimated to total $100,000 per year.

Reconstruction in the Soda Hill tunnels was under the direction of H. A. Van Norman, chief engineer and general manager, Los Angeles Bureau of Water Works and Supply. J. E. Phillips is engineer in charge of maintenance and operation, Owens Valley Aqueduct, and R. F. Goudey is sanitary engineer for the bureau.

Results of the reconstruction work were announced in a paper presented by Mr. Phillips at the recent Sacramento meeting of the California Section American Water Works Association.

Plowing Six-Feet Deep

PLOWS LARGE ENOUGH to make furrows 6 ft. deep are in use in Southern California. The idea for such equipment, in some respects resembling a deep subsoiler plow, came about as the result of flood damage to valuable agricultural lands in the lower Santa Ana River basins. In 1916 flood waters twice left a deep, non-productive cover of river sand over thousands of acres of highly developed land. Numerous methods of reclamation were tried only to be given up as uneconomical. Hence much of this land was abandoned until about five years ago when experiments began on soil replacement by deep plowing. Plows of larger and larger size were tried until it was found that soil covered with as much as 5 ft. of river sand could be economically restored by bringing up to the surface the original top-soil and burying the sand.

Although forerunners of the present plows have been in operation for about five years, it is only within the last year that their design and construction have been standardized, partly with the idea that such equipment can be used effectively in laying pipe lines, throwing up levees and in flood-control work generally.

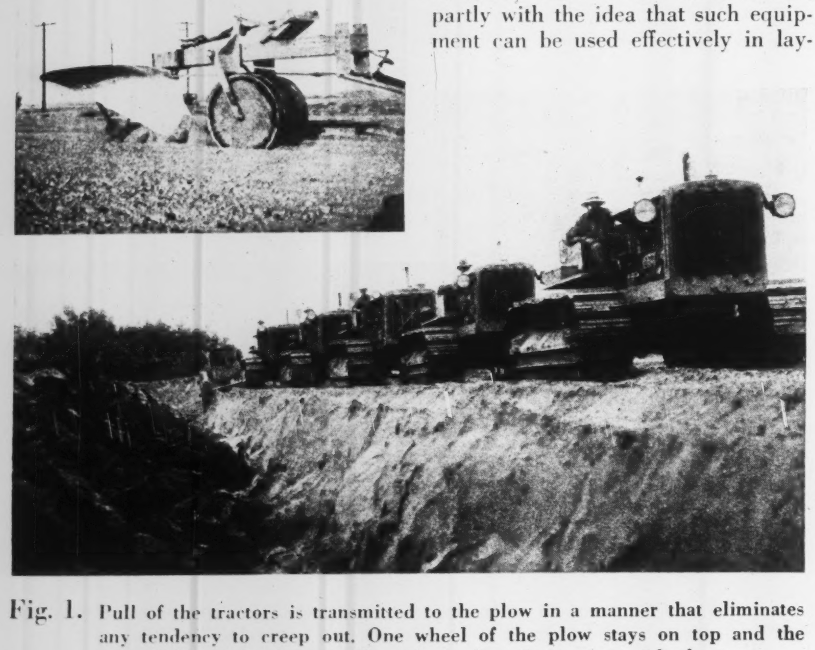


Fig. 1. Pull of the tractors is transmitted to the plow in a manner that eliminates any tendency to creep out. One wheel of the plow stays on top and the other follows the furrow. (Insert) A plow that turns a 6-ft. furrow.

In their present form the plows have a central member consisting of a welded steel box to which the several parts are attached. Through this box the tractive effort is transmitted and on it are mounted the operating mechanism, wheels and plow proper. Complete control is effected by a single lever located on the rear tractor and operated by the tractor driver. This lever controls a hydraulic pump (also mounted on the tractor) from which high pressure hose lines lead to an operating ram on the plow. The two wheels, mounted on a single axle, are so connected that the wheel on the left can swing upward to follow the ground surface while the right wheel follows the previously plowed furrow, lifting only enough to compensate for the natural back-fall. The furrow width, in all three sizes, is 2½ ft. The connection between tractor and plow consists of two steel tubes separated at the plow and converging to a junction at the tractor, thereby making it possible for the tractor to control direction of movement accurately.

Design of the mounting has been developed, it is claimed, so that there is no tendency for the plow to creep in or out, or otherwise to deviate from the prescribed working position and the control ram holds the cutting edge at any depth, up to the maximum, with equally effective turnover. The usual practice is to pull the plow from the surface down into operating position or back again to the surface without changing speed. Costs vary considerably with vegetation, condition and kind of soil.

The plows were designed and developed by C. R. Post of the firm of Post Brothers, Santa Ana, Calif.

BOOK NOTES AND REVIEWS

The month's additions to the engineer's reading and reference list

Tall Chimney Design

A PRACTICAL TREATISE ON CHIMNEY DESIGN—By David A. Molitor. 123 pp. Published by The Peters Co., Detroit, Mich. Price $2.50.

Literature on chimney design is fragmentary and scattered. Methods of stress analysis have been presented and record-breaking stacks and chimneys have been described, but a concise and comprehensive treatise on the subject has been lacking. Mr. Molitor now furnishes such a treatise.

Tables for expediting calculation are given throughout the book and many problems are presented with their solution. Of special interest is the design of a 180 ft. x 7 ft. 6 in. round chimney of brick, of reinforced concrete and of steel.

The first of the two pages on "Wind Pressure" in Chapter 3 can be read with profit by every designer of tall structures.

Chapter 5, "Chimney Foundations", is an important chapter. The necessity of an accurate knowledge of soil conditions before a trustworthy foundation can be designed is emphasized. Chapter 8, "Steel Chimneys", has great value. The wind pressure and unit working stresses recommended are conservative; in competitive designing they might be regarded as ultra-conservative. *Reviewed by* ROBINS FLEMING, *American Bridge Co., New York.*

Engineers and Humorist

JOHN PHOENIX, ESQ., the Veritable Squibob: A Life of Captain George H. Derby, U. S. A.—By George R. Stewart. 242 pp. Published by Henry Holt & Co., New York. Price $2.50.

By common consent the first notable American humorist was an engineer. Born at Medfield, Mass., graduated at West Point in 1846, George H. Derby was assigned to the Corps of Topographical Engineers. Although detailed to various stations from Massachusetts to Washington, including brief service in the Mexican War under General Scott, where he was severely wounded, Derby spent the larger part of his brief adult life in California. He was there during the gold rush and later pioneer days. The variegated and tumultuous life of those days appealed to his sense of humor and was recorded both graphically and verbally by his facile pen.

Aside from his professional reports, which are listed by Mr. Stewart, most of Derby's writings made their first appearance in the early newspapers of San Diego and San Francisco. As his fame grew some appeared in the East, particularly in the *Knickerbocker Magazine* of New York. In 1855 many of these writings were collected and published in New York under the title "Phoenixianna."

Stewart's biography portrays Captain Derby as a man, an army engineer and throughout as a humorist. It should appeal to all who are interested in types of American humor, as affected by time and place. It is a welcome addition to the short list of biographies of American engineers.—*Reviewed by* M. N. BAKER, *Upper Montclair, N. J.*

Boulder Dam Studies

BOULDER CANYON PROJECT, FINAL REPORTS—Part VI—Hydraulic Investigations: Bulletin 1, Model Studies of Spillways; Bulletin 2, Model Studies of Penstocks and Outlet Works. 190 and 165 pp. respectively. Prepared and published by the Bureau of Reclamation, Customhouse, Denver, Colo. Price in U. S. A., each $1.00 (paper) $1.50 (cloth).

In Bulletin 1 the method of procedure followed in the Boulder Dam studies is described in detail from the time at which experiments were begun on the glory-hole spillway to the completion of the studies on the final side-channel spillway design. Interesting comparisons are made of the three models used to obtain checks on prototype action. Results are included also from tests on concrete blocks subjected to the action of a continuous stream of water, issuing from a nozzle, at velocities between 100 and 175 ft. per sec.

A complete account is given in Bulletin 2 of the following investigations: junctions between penstocks and headers; losses and pressure conditions in the intake towers; flow characteristics of needle valves in tunnel-plug outlets; and hydraulic conditions in the river downstream from the powerhouse.

Excellent insight into the field of experimentation on hydraulic structures is provided by these bulletins. The material included therein will be of especial interest to those engaged in the practice of hydraulic engineering. *Reviewed by* GEO. W. HOWARD. *U. S. Waterways Experiment Station, Vicksburg, Miss.*

These two books are the first of a long series that will make up the final reports on the Boulder Canyon Project.—EDITORS.

Air Conditioning Data

AIR CONDITIONING IN SUMMER AND WINTER—By Richard E. Holmes. 296 pp. Published by McGraw-Hill Book Co., New York and London. Price $3.

HEATING, VENTILATING, AND AIR CONDITIONING FUNDAMENTALS—By William H. Severns. 467 pp. Published by John Wiley & Sons, New York and Chapman & Hall, London. Price $4.

HEATING, VENTILATING, AND AIR CONDITIONING GUIDE-1938—Vol. 16. 1,268 pp. Published by the American Society of Heating and Ventilating Engineers, New York. Price $5.

TRANE AIR CONDITIONING MANUAL—By William Goodman. 66 pp. Published by The Trane Co., La Crosse, Wis. Price $5.

Evidence of growing interest in air conditioning is found in the number of new books on the subject that are coming off the presses. Of the four books listed above two are given over entirely to air conditioning and two include heating and ventilating, but it is interesting to note that the space given to air conditioning in the A.S.H.V.E. Guide has increased steadily until it takes up a large part of the volume. As in past editions, one section of the Guide is given over to brief descriptions of new products put out by manufacturers of equipment used in the field of the book.

Mr. Holmes' book is the outgrowth of his two years' experience in teaching men in the Westinghouse plant who were preparing to enter the air-conditioning industry. It is prepared to serve as a text book in schools and covers the subject concisely.

Similarly, Prof. Severns' book has been prepared as a text for students, but its scope is broader as both heating and ventilating are included as well as air conditioning. Both books are freely illustrated with diagrams and with sketches of types of equipment in current use.

The Trane manual is unique as a piece of literature put out by a manufacturer of air-conditioning equipment. Its original purpose was to educate the company's own salesmen in order that they could answer prospects' questions intelligently, thus greatly increasing their usefulness and at the same time helping them to make sales. As now developed it presents the subject largely by working out many typical examples of problems encountered in practice. The tables, collected from many sources, are particularly valuable.

Many work sheets for field use are included.

Story of a Great Bridge

THE GOLDEN GATE BRIDGE—Report of the Chief Engineer to the Board of Direction of the Golden Gate Bridge & Highway District, 246 pp. Published by The Golden Gate Bridge and Highway District, San Francisco. Price $6, limited edition.

Departing from usual practice in engineering reports, the late J. B. Strauss in his "report of the chief engineer" presented the board of directors of the Golden Gate Bridge and Highway District with a highly interesting and profusely illustrated book, which tells the story of this great bridge from the inception of its promotion to its final completion. While lacking some of the documentary evidence and detailed consideration of controversial points that engineers might expect and like to see, the omissions do not detract from the usefulness of the book for the general engineering reader. The subject matter is divided into five parts —general history, planning, construction, materials and fabrication. Each is covered in from 40 to 70 pages and taken together they comprise a piece of engineering literature that will prove inspiring and instructive to both young and mature members of the profession in both field and office.

MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

A Carpenter's Manual giving details of methods of application of the several types of Celotex building board to interior finish can be obtained from the Public Relations Department, The Celotex Corp., Chicago.

Civil Service Agencies is the title of a pamphlet giving the number of merit-system agencies in this country, their legal bases, and organizational structure. Copies may be obtained from the Civil Service Assembly, 850 East 58th St., Chicago. Price 50c.

A Steel Products Manual is being published in loose-leaf form by the American Iron & Steel Institute, 350 Fifth Ave., New York. The manual is to be issued in sections, not necessarily in consecutive order. The two first issued are Section 19, Railway Track Materials, and Section 20, Wrought-Steel Wheels. Single copies sell for 15c. each.

Construction Volume reached a total of $14,000,000,000 in 1927, fell to $4,000,000,000 in 1933, and now is about $8,000,000,000 according to a new publication of the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, entitled Construction Activities in the United States, 1915-37. The increase in construction of community services in recent years stands out as notable. Price, 15c.

NEW PUBLICATIONS

ELEMENTARY THERMODYNAMICS—By Virgil M. Faires. 225 pp. Published by The Macmillan Co., New York. Price $2.60.

APPLIED THERMODYNAMICS — By Virgil M. Faires. 374 pp. Published by The Macmillan Co., New York. Price $3.90.

PROBLEMS ON APPLIED THERMODYNAMICS—By Virgil M. Faires and Alexander V. Brewer. 137 pp. Published by The Macmillan Co., New York. Price $1.40 (paper cover).

THE MASTER PLAN—By Edward M. Bassett. 151 pp. Published by the Russell Sage Foundation, New York. Price $2.00.

DIE STATIK DER BAUWERKE — By Rudolph Kirchhoff. 236 pp. Published by Wilhelm Ernst & Sohn, Berlin W9. Price 13.50RM (paper cover).

GEOLOGY AND GROUND-WATER RESOURCES OF SOUTH-CENTRAL NEBRASKA—Water Supply Paper 779. By A. L. Lugn and L. K. Wenzel. 242 pp. Published by the U. S. Geographical Survey. Price 70c from Superintendent of Documents, Washington, D. C.

TIMBER, ITS STRUCTURE AND PROPERTIES—By H. E. Desch. 169 pp. Published by Macmillan and Co., London, and The Macmillan Co., New York. Price $4.50.

MEASURING MUNICIPAL ACTIVITIES —By Clarence E. Ridley and Herbert A. Simon. 102 pp. Published by the International City Managers' Association, Chicago. Price $2.

WATER SUPPLY AND SEWERAGE—By Ernest W. Steel. 653 pp. Published by McGraw-Hill Book Co., New York & London. Price $5.

FISH PASSES—By T. E. Pryce-Tannatt. 108 pp. Published by Edward Arnold & Co., London W1. Price 3/6 net.

SIMPLIFIED ENGINEERING FOR ARCHITECTS AND BUILDERS—By Harry Parker. 214 pp. Published by John Wiley & Sons, New York and Chapman & Hall, Ltd., London. Price $2.75.

MEN AND IRON—The History of the New York Central—By Edward Hungerford. 424 pp. Published by Thomas Y. Crowell Co., New York. Price $3.75.

AIRPLANE STRUCTURES—Vol II, Second Edition. By Alfred S. Niles and Joseph S. Newell. 177 pp. Published by John Wiley & Sons, New York and Chapman & Hall, London. Price $2.75.

ELEMENTS OF STRUCTURAL ENGINEERING—By Edward S. Sheiry. 475 pp. Published by the International Textbook Co., Scranton, Pa. Price $4.

STRENGTH OF MATERIALS—By Norman C. Riggs and Max M. Frocht. 432 pp. Published by the Ronald Press Co., New York. Price $3.75.

PRINCIPLES OF ENGINEERING ECONOMY—Revised Edition. By Eugene L. Grant. 431 pp. Published by the Ronald Press Co., New York. Price $3.75.

GAS ANALYSIS—By A. McCulloch. 166 pp. Published by H. F. & G. Witherby, Ltd., London, WC1. Price 7/6 net.

ROADS, CANALS AND EMBANKMENTS WITH CATERPILLAR EQUIPMENT—By F. A. Nikirk. 182 pp. Published by the Caterpillar Tractor Co., Peoria, Ill. Price 50c. (paper cover).

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